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NASA BUDGET ANALYSIS FY68

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B U D G E T   A N A L Y S I S

FY 1968

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T A B L E   O F   C O N T E N T S

FY 1968 BUDGET NATIONAL AERONAUTICS & SPACE ADMINISTRATION

A total program of $5,110,000,000 is requested by NASA, to be financed by $5,050,000,000 in new obligational authority and $60,000,000 of prior year funds, to maintain effort in current programs at a level deemed important to the maintenance of the United States world position in space and aeronautics.

The industrial community, under contracts with the NASA, will continue to carry forward the prime design, development and fabrication effort of the NASA program. Specific elements of the activity will continue to be pursued within NASA installations, other government agencies, universities and research contractors which have the necessary level of expertise in special areas of engineering and science. The major elements of the program fall within the following categories:

MANNED SPACE FLIGHT: A program for the development of a capability for peaceful manned space operations and the utilization of that capability for earth orbit and lunar missions.

SPACE SCIENCE AND APPLICATIONS: An unmanned space flight program directed toward scientific investigations of the earth, moon, sun, planets, stars and interplanetary space; and the development of technology and spacecraft systems which can be utilized for meteorology, communications and geodetic observations.

integration, test, and preparation for launch of Sunblazer A. Experiment funding will allow for the pre-launch formating and programming of the propagation experiment.

	Fiscal Year 1967	Fiscal Year 1968
Lunar and Planetary Program		
Mariner Mars 1971	---	$10,100,000

The Mariner Mars 1971 project will launch two spacecraft which will not only obtain pictures of the surface of that planet with substantially higher resolution than those to be taken by Mariner Mars 1969, but will also secure qualitative data on atmospheric constituents and structure by injecting a scaled down Voyager capsule into the Martian atmosphere. This should lead to better development of the Voyager capsule program. The funds requested for FY 1968 will establish the functional specifications, complete the systems design, and provide for extensive development and testing of prototypes of critical subsystems.

	Fiscal Year 1967	Fiscal Year 1968
Space Applications Program		
Nimbus (E&F)	---	$5,000,000

These missions will continue the development of improved meteorological satellites to provide data for meteorologists; prove instrumentation; fulfill special data requirements of the atmospheric sciences research community; and provide the basis for further technological advances in meteorological satellites for scientific and operational uses. Two launches will continue the Nimbus series. FY 1968 funds are required for final definition of the spacecraft and to start procurement of long leadtime spacecraft components and experiments.

	Fiscal Year 1967	Fiscal Year 1968
Applications Technology Satellites (F&G)	---	$15,700,000

The objectives are to develop the technology for erecting and accurately pointing large antennas in space; to investigate the technology of accurate angle measurement in space using an interforometer; to investigate the technology for multi-beam phased array antennas in space; and conduct other experiments requiring an accurately stabilized platform in geostationary orbit. Two flights are planned in the 1970-71 period for launch at synchronous orbit as follow-on flights in the current ATS series. FY 1968 funds are required for detailed study, analysis and preliminary design of the spacecraft and associated ground system modification, and for definition and development of experiments in the communications, meteorological, navigation and geodesy areas.

	Fiscal Year 1967	Fiscal Year 1968
Voice Broadcast Satellite	---	$2,300,000

The objectives of this project are to develop the capability and demonstrate the feasibility of broadcasting aural program material directly to conventional FM and/or shortwave AM radios. The spacecraft transponder may be wideband. This makes possible an alternative mode permitting transmission of TV program material to specifically designed receivers for experimental purposes. Two flights are planned in the 1971-72 period to test the necessary equipment aboard a large spacecraft structure. The FY 1968 funds are required for definition studies and systems analysis.

FY 1968 NASA Budget

The FY 1968 Appropriations Bill, to be enacted shortly by Congress if the requested amount is approved calls for the following:

Research and Development

1. Apollo, $2,546,500,000
2. Apollo Applications, $454,700,000
3. Advanced Missions, $8,000,000
4. Physics and Astronomy, $147,500,000
5. Lunar and Planetary Exploration, $142,000,000
6. Voyager, $71,500,000
7. Bioscience, $44,300,000
8. Space Applications, $104,200,000
9. Launch Vehicle Procurement, $165,100,000
10. Space Vehicle Systems, $37,000,000
11. Electronic Systems, $40,200,000
12. Human Factor Systems, $21,000,000
13. Basic Research, $23,500,000
14. Space Power and Electric Propulsion Systems, $45,000,000
15. Nuclear Rockets, $46,500,000
16. Chemical Propulsion, $38,000,000
17. Aeronautics, $66,800,000
18. Tracking and Data Acquisition, $297,700,000

19. Sustaining University Program, $20,000,000

20. Technology Utilization, $5,000,000

Construction of Facilities

These items, including land acquisitions, are as follows:

1. Ames Research Center, Moffett Field, California, $5,365,000.

2. Electronics Research Center, Cambridge, Massachusetts, $6,220,000.

3. Goddard Space Flight Center, Greenbelt, Maryland, $565,000.

4. Jet Propulsion Laboratory, Pasadena, California, $3,125,000.

5. John F. Kennedy Space Center, NASA, Kennedy Space Center, Florida, $24,885,000.

6. Lewis Research Center, Cleveland and Sandusky, Ohio, $2,115,000.

7. Manned Spacecraft Center, Houston, Texas, $2,425,000.

Administrative Operations

A budget request of $671,300,000 is requested for this cost-of-doing-business item.

NASA FY 1968 BUDGET

SUMMARY OF BUDGET PLAN BY APPROPRIATION BY BUDGET ACTIVITY

(Thousands of dollars)

APPROPRIATION TITLE	TOTAL	MANNED SPACE FLIGHT	SCIENTIFIC INVESTI-GATIONS IN SPACE	SPACE APPLI-CATIONS	SPACE TECHNOLOGY	AIRCRAFT TECHNOLOGY	SUPPORTING ACTIVITIES
Fiscal Year 1966	$5,152,405	$3,530,253	$689,043	$115,261	$403,692	$80,351	$333,805
Research and development	4,483,011	3,199,507	608,840	102,853	248,500	41,496	281,815
Construction of facilities	58,208	17,478	8,024	---	13,435	682	18,589
Administrative operations	611,186	313,268	72,179	12,408	141,757	38,173	33,401
Fiscal Year 1967	$4,907,583	$3,398,226	$559,493	$112,185	$384,745	$103,396	$349,538
Research and development	4,175,100	3,024,000	475,500	99,000	233,850	35,900	306,850
Construction of facilities	85,000	43,821	4,879	---	8,589	21,011	6,700
Administrative operations	647,483	330,405	79,114	13,185	142,306	46,485	35,988
Fiscal Year 1968	$5,110,000*	$3,435,780*	$602,540	$161,025	$424,317	$119,567	$366,771
Research and development	4,384,500*	3,069,200*	516,316	147,284	262,200	66,800	322,700
Construction of facilities	54,200	27,900	6,985	---	8,335	3,170	7,810
Administrative operations	671,300	338,680	79,239	13,741	153,782	49,597	36,261

*Includes $60 million of prior year funds applied to FY 1968 budget plan.

FY 1968 NASA RESEARCH AND DEVELOPMENT PROGRAMS

BUDGET PLAN

	(In thousands of dollars) FY 1966	FY 1967	FY 1968
MANNED SPACE FLIGHT	3,199,507	3,024,000	3,069,200
Gemini	197,275	21,600	---
Apollo	2,940,985	2,916,200	2,606,500
Apollo applications	51,247	80,000	454,700
Advanced mission studies	10,000	6,200	8,000
SPACE SCIENCE AND APPLICATIONS	759,093	607,100	694,600
Physics and astronomy	142,753	129,800	147,500
Lunar and planetary exploration	204,300	169,400	142,000
Voyager	17,097	10,450	71,500
Sustaining university program	46,000	31,000	20,000
Launch vehicle development	57,790	31,200	---
Launch vehicle procurement	178,700	122,400	165,100
Bioscience	34,400	41,550	44,300
Space applications	78,053	71,300	104,200
ADVANCED RESEARCH AND TECHNOLOGY	288,596	268,150	318,000
Basic research	22,000	21,465	23,500
Space vehicle systems	35,000	33,935	37,000
Electronics systems	32,300	33,597	40,200
Human factor systems	14,900	16,175	21,000
Space power and electric Propulsion systems	45,200	40,440	45,000
Nuclear rockets	58,000	53,000	46,500
Chemical propulsion	39,700	33,638	38,000
Aeronautics	41,496	35,900	66,800
TRACKING AND DATA ACQUISITION	231,065	270,850	297,700
TECHNOLOGY UTILIZATION	4,750	5,000	5,000
TOTAL	4,483,011	4,175,100	4,384,500

NASA FY 1968

MANNED SPACE FLIGHT

BUDGET PLAN

(In thousands of dollars)

	FY 1966	FY 1967	FY 1968
GEMINI	197,275	21,600	---
Spacecraft	98,872	9,150	---
Launch vehicles	72,900	2,900	---
Support	25,503	9,550	---
APOLLO	2,940,985	2,916,200	2,606,500
Spacecraft	1,233,800	1,250,300	1,036,300
Uprated Saturn I	274,786	236,600	156,200
Saturn V	1,134,871	1,135,600	1,108,500
Engine development	133,200	49,800	24,500
Mission support	164,328	243,900	281,000
APOLLO APPLICATIONS	51,247	80,000	454,700
Space vehicles	8,500	38,600	263,700
Experiments	40,347	35,600	140,700
Mission support	2,400	5,800	50,300
ADVANCED MISSION STUDIES	10,000	6,200	8,000
TOTAL MANNED SPACE FLIGHT	3,199,507	3,024,000	3,069,200

FY 1968

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SPACE SCIENCE AND APPLICATIONS

BUDGET PLAN

	(In thousands of dollars)		
	FY 1966	FY 1967	FY 1968
PHYSICS AND ASTRONOMY	142,753	129,800	147,500
Supporting research and technology/ advanced studies	20,594	19,900	19,900
Solar observatories	19,052	9,800	11,900
Astronomical observatories	22,300	27,700	40,600
Geophysical observatories	28,215	24,000	20,000
Pioneer	12,700	7,200	7,500
Explorers	18,592	19,200	21,600
Sounding rockets	19,300	20,000	22,000
Sunblazer	--	--	2,000
Data analysis	2,0000	2,0000	2,000
LUNAR AND PLANETARY EXPLORATION	204,300	169,400	142,000
Supporting research and technology/ advanced studies	23,000	20,900	20,900
Ranger	1,000	--	--
Surveyor	104,634	84,500	42,200
Lunar orbiter	58,081	28,800	10,000
Mariner	17,858	35,200	68,900
VOYAGER............................	17,097	10,450	71,500
SUSTAINING UNIVERSITY PROGRAM	46,000	31,000	20,000
Training	25,290	16,000	7,000
Research facilities	7,850	4,000	3,000
Research	12,860	11,000	10,000
LAUNCH VEHICLE DEVELOPMENT	57,790	31,200	--
Supporting research and technology/ advanced studies	4,000	4,000	--
Centaur development	53,790	27,200	--

FY 1968 BUDGET

	(In thousands of dollars)		
	FY 1966	FY 1967	FY 1968
LAUNCH VEHICLE PROCUREMENT	178,700	122,400	165,100
Supporting research and technology	--	--	4,000
Scout	11,700	9,400	16,800
Delta	27,729	20,900	32,600
Agena	70,669	37,100	24,700
Centaur	65,000	55,000	87,000
Atlas	3,602	--	--
BIOSCIENCE	34,400	41,550	44,300
Supporting research and technology	11,100	11,550	14,300
Biosatellites	23,300	30,000	30,000
SPACE APPLICATIONS	78,053	71,300	104,200
Supporting research and technology	10,839	11,630	16,600
Tiros/TOS improvements	2,500	3,100	7,500
Nimbus	22,560	23,400	34,500
Meteorological soundings	2,730	3,000	3,000
French satellite (FR-2)	--	100	100
Voice broadcast satellite	--	--	2,300
Applications technology satellites	34,431	28,470	35,500
Geodetic satellite	4,993	1,600	4,700
TOTAL SPACE SCIENCE AND APPLICATIONS	759,093	607,100	694,600

FY 1968 BUDGET

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

ADVANCED RESEARCH AND TECHNOLOGY

BUDGET PLAN

	(In thousands of dollars)		
	FY 1966	FY 1967	FY 1968
BASIC RESEARCH (Supporting research and technology)	22,000	21,465	23,500
SPACE VEHICLE SYSTEMS	35,000	33,935	37,000
Supporting research and technology	26,450	26,635	29,000
FIRE	50	--	--
Lifting-body flight and landing tests	1,000	1,000	1,000
Scout re-entry	3,000	4,050	4,500
Project Pegasus	1,500	--	--
Small space vehicle flight experiments	3,000	2,250	2,500
ELECTRONICS SYSTEMS	32,300	33,597	40,200
Supporting research and technology	29,848	31,797	39,200
Flight projects	2,452	1,800	1,000
HUMAN FACTOR SYSTEMS	14,900	16,175	21,000
Supporting research and technology	13,000	14,675	19,500
Small biotechnology flight projects	1,900	1,500	1,500
SPACE POWER AND ELECTRIC PROPULSION SYSTEMS	45,200	40,440	45,000
Supporting research and technology	38,200	34,940	34,200
Space electric rocket test (SERT)	3,200	--	1,100
SNAP-8 development	4,000	5,500	9,700
NUCLEAR ROCKETS	58,000	53,000	46,500
Supporting research and technology	20,644	16,506	16,500
Nuclear rocket development station operations	2,000	3,000	4,000
NERVA	35,356	33,494	26,000

FY 1968 BUDGET

	(In thousands of dollars)		
	FY 1966	FY 1967	FY 1968
CHEMICAL PROPULSION	39,700	33,638	38,000
Supporting research and technology	32,950	30,138	38,000
M-1 engine project	2,000	--	--
Large solid motor project	4,750	3,500	--
AERONAUTICS	41,496	35,900	66,800
Supporting research and technology	10,186	9,582	18,600
X-15 research aircraft	883	878	4,000
Supersonic transport	12,331	11,090	11,100
V/STOL aircraft	3,200	5,550	7,100
Hypersonic ramjet experiment	5,000	2,000	7,000
XB-70 flight research program	9,896	2,000	10,000
Aircraft noise reduction	--	4,800	3,500
Quiet engine development	--	--	2,000
Delta X-15 aircraft	--	--	1,000
F-111 aircraft	--	--	500
F-106 aircraft	--	--	2,000
TOTAL ADVANCED RESEARCH AND TECHNOLOGY	288,596	268,150	318,000

FY 1968 Budget

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

TRACKING AND DATA ACQUISITION

BUDGET PLAN

	(In thousands of dollars)		
	FY 1966	FY 1967	FY 1968
TRACKING AND DATA ACQUISITION	231,065	270,850	297,700
Operations	127,510	197,400	228,800
Equipment	89,755	59,650	55,100
Supporting research and technology	13,800	13,800	13,800

TECHNOLOGY UTILIZATION

TECHNOLOGY UTILIZATION	4,750	5,000	5,000

FY 1968 BUDGET

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

CONSTRUCTION OF FACILITIES

	(In thousands of dollars)		
	FY 1966	FY 1967	FY 1968
INSTALLATIONS			
MANNED SPACE FLIGHT	13,350	45,558	30,190
John F. Kennedy Space Center, NASA	6,917	35,758	24,885
Manned Spacecraft Center	4,180	9,100	2,425
Marshall Space Flight Center	1,956	--	870
Michoud Assembly Facility	297	700	2,010
SPACE SCIENCE AND APPLICATIONS	4,388	1,265	4,430
Goddard Space Flight Center	2,400	710	565
Jet Propulsion Laboratory	940	350	3,125
Wallops Station	1,048	205	740
ADVANCED RESEARCH AND TECHNOLOGY	16,866	29,600	13,700
Ames Research Center	2,749	--	5,365
Electronics Research Center	5,000	7,500	6,220
Langley Research Center	8,250	6,100	--
Lewis Research Center	867	16,000	2,115
VARIOUS LOCATIONS	19,376	3,577	2,880
FACILITY PLANNING AND DESIGN	4,228	5,000	3,000
TOTAL	58,208	85,000	54,200

(In thousands of dollars)

PROJECTS BY INSTALLATION

JOHN F. KENNEDY SPACE CENTER, NASA	24,885
Launch Complex 39	16,660
Alteration and Rehabilitation of Launch Complexes 34 and 37	5,725
Alterations to Launch Complex 17	2,290
Utilities Installation	210
MANNED SPACECRAFT CENTER	2,425
Modifications to the Environmental Testing Laboratory	1,900
Center Support Facilities	525
MARSHALL SPACE FLIGHT CENTER	870
Water Pollution Control	350
Fire Surveillance System	520
MICHOUD ASSEMBLY FACILITY	2,010
Extension of Saturn Boulevard to State Road System	1,130
Repair, Rehabilitation and Improvements	880
GODDARD SPACE FLIGHT CENTER	565
Utility Modification and Installation	565
JET PROPULSION LABORATORY	3,125
Standby Power Plant for Space Flight Operations Facility Deep Space Network	1,930
Space Flight Operations Facility Systems Development Laboratory	1,195
WALLOPS STATION	740
Power and Steam Distribution System Renovation	740
AMES RESEARCH CENTER	5,365
Space Sciences Research Laboratory	2,195
Heater Replacement, 3.5 Foot Wind Tunnel	3,170

(cont'd.)

FY 1968 BUDGET

	(In thousands of dollars)
ELECTRONICS RESEARCH CENTER	6,220
Qualifications and Standards/Components Technology Special Purpose Laboratory	4,200
Center Support Facilities III	2,020
LEWIS RESEARCH CENTER	2,115
Land Acquisition (Plumbrook)	2,100
Land Acquisition (Cleveland)	15
VARIOUS LOCATIONS	2,880
Phased Array Antenna System (Goldstone)	2,880
FACILITY PLANNING AND DESIGN	3,000
TOTAL	54,200

FY 1968 BUDGET

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

ADMINISTRATIVE OPERATIONS

INSTITUTIONAL DIRECTOR AND INSTALLATION	(In thousands of dollars) FY 1966	FY 1967	FY 1968
MANNED SPACE FLIGHT	296,936	315,400	323,500
John F. Kennedy Space Center, NASA	81,952	92,658	99,575
Manned Spacecraft Center	86,543	94,989	97,636
Marshall Space Flight Center	128,441	127,753	126,289
SPACE SCIENCE AND APPLICATIONS	73,702	81,222	82,428
Goddard Space Flight Center	64,365	71,211	72,240
Wallops Station	9,337	10,011	10,188
ADVANCED RESEARCH AND TECHNOLOGY	180,671	187,100	200,200
Ames Research Center	33,211	33,739	33,954
Electronics Research Center	6,346	12,252	19,264
Flight Research Center	9,380	9,485	9,630
Langley Research Center	63,529	63,302	68,265
Lewis Research Center	66,383	66,283	66,996
Space Nuclear Propulsion Office ...	1,822	2,039	2,091
NASA HEADQUARTERS	59,877	63,761	65,172
TOTAL	611,186	647,483	671,300

OFFICE OF MANNED SPACE FLIGHT PROGRAM OBJECTIVES

APOLLO PROGRAM

The goal for Apollo is a manned space flight capability which will achieve and maintain a position of leadership in space for the United States. An immediate objective is landing men on the moon and returning them safely to earth within this decade. The Apollo program, should meet the near-term objective, but should also build a broad base of operational capability in manned space flight and associated skills and technology; a valuable complex of development, manufacturing, test, and operational facilities; and an experienced government and industrial team.

To accomplish the immediate goal of lunar landing and return, the Apollo program has focused on the development of a highly reliable spacecraft, which is capable of supporting three men in space for periods up to two weeks, docking in space, landing on and returning from the lunar surface, and safely reentering the earth's atmosphere. The program includes three large launch vehicles--the Saturn I, which completed its flight series in 1965; the Uprated Saturn I; and the Saturn V.

The Apollo program is divided into unmanned flights, manned earth orbital flights, and manned lunar flights. Unmanned Apollo Uprated Saturn I flights have demonstrated the structural integrity and the spacecraft and adapter with the launch vehicle; the firing and restarting of the spacecraft engines; the ability of the command module heatshield to withstand high speed re-entry; and the operational readiness of the ground support and recovery crews. The three unmanned flights conducted during 1966 have qualified the Uprated Saturn I for manned missions.

Funds for FY 1968 are required to support a period of intensive flight activity. Manned earth orbital rendezvous operations will be conducted using the Uprated Saturn I launch vehicles. In addition, heavy emphasis will be placed on Apollo Saturn V flight qualification to demonstrate the efficiency of the ground support network and to validate the operational reliability of the spacecraft and launch vehicle systems. These steps lead to the complex lunar mission simulations which precede manned lunar landing and return.

RESOURCES REQUIRED:

	1966	1967	1968
Spacecraft	$1,233,800,000	$1,250,300,000	$1,036,300,000
Uprated Saturn I	274,786,000	236,600,000	156,200,000
Saturn V	1,134,871,000	1,135,600,000	1,108,500,000
Engine development	133,200,000	49,800,000	24,500,000
Mission support	164,328,000	243,900,000	281,000,000
Total program plan	$2,940,985,000	$2,916,200,000	$2,606,500,000
Unobligated balance available to finance new program plan			-60,000,000
Total new authority requested			$2,546,500,000

Distribution of Programs:

John F. Kennedy Space Center, NASA	$128,109,000	$223,450,000	$228,500,000
Manned Spacecraft Center	1,279,394,000	1,350,073,000	1,160,400,000
Marshall Space Flight Center	1,506,935,000	1,314,096,000	1,188,100,000
Goddard Space Flight Center	425,000	93,000	100,000
Ames Research Center	230,000	---	---
Langley Research Center	---	170,000	---
NASA Headquarters	23,022,000	28,118,000	29,400,000
Western Support Office	2,870,000	200,000	---

Spacecraft

	1966	1967	1968
Command and service modules	$612,799,000	$560,400,000	$494,000,000
Lunar module	362,615,000	472,500,000	373,100,000
Guidance and navigation	137,169,000	76,654,000	55,400,000
Integration, reliability, and checkout	32,334,000	29,975,000	23,200,000
Spacecraft support	88,883,000	110,771,000	90,600,000
Total	$1,233,800,000	$1,250,300,000	$1,036,300,000

The Apollo spacecraft, which stands 54 feet high (excluding the launch escape system) and weighs approximately 95,000 pounds, is composed of three modules: the command module, the service module, and the lunar module.

The command module, which is the recoverable portion of the Apollo spacecraft, houses the three astronauts in a controlled environment. The coneshaped command module is approximately 11 feet high and 13 feet in diameter at the larger end. Life support and communications systems, as well as control systems for in-flight and re-entry maneuvers, are contained in this module.

The service module, which is 14 feet high and 13 feet in diameter, contains the propulsion system used for mid-course corrections on the way to the moon, injection into lunar orbit, and ejection from lunar orbit for the return trip to earth. Additional utilities are also carried in the service module. The unit is jettisoned on the return trip after it has performed mid-course corrections required to place the command module into the proper moon-to-earth trajectory.

The lunar module, which is 20 feet high and 19 feet in diameter, is a selfcontained vehicle comprised of a descent stage with landing legs and an ascent stage with a habitable two-man cabin. During the launch phase, the lunar module is enclosed in an adapter, which also serves as a structural support to join the Apollo spacecraft and the Saturn launch vehicle.

This spacecraft, launched by a Saturn V, will be used for manned lunar landing and return before the end of this decade. The mission plan for achieving this national goal is based on a step-by-step progression from one checkpoint to the next. After launch from the John F. Kennedy Space Center (KSC), the Apollo spacecraft, with the Saturn V 3rd Stage still attached, will be inserted into a 100 nautical mile earth-parking orbit, and tracked by the world-wide Manned Space Flight Network stations. As the spacecraft orbits the earth, a thorough crew and equipment checkout will be conducted to verify that the systems are operating effectively and are ready for the lunar mission. When the crew and systems readiness have been confirmed and the precise translunar injection window has been determined, the Saturn V 3rd Stage (the S-IVB) will be restarted. The S-IVB will accelerate the spacecraft to the seven-mile-a-second velocity required to escape the earth's gravity, and move into a translunar path. After a detailed checkout procedure, the astronauts will separate the command and service module from the combination of the lunar module, S-IVB, and instrument unit, turn their craft around, and dock with the lunar module. The adapter section, S-IVB, and instrument unit, will be jettisoned after this docking maneuver is completed. The next step will involve mid-course corrections using the service module propulsion to keep the spacecraft on the right path to the moon. At the proper time, the service module propulsion system will again be fired to slow down the spacecraft and inject it into orbit around the moon. The astronauts, in communication with the ground stations on earth, will conduct a thorough checkout of all systems. Provided that the outlook is favorable, two of the three Apollo astronauts will transfer from the command module to the lunar module, separate from the command craft (which remains in lunar orbit) and prepare to land on the moon. The lunar module's descent engine will be fired to provide the deceleration required to escape from lunar orbit and descend to the surface of the moon. After collecting lunar samples and implanting experiment equipment and instrumentation, the two Apollo astronauts will return to the lunar module and perform an extensive systems checkout in preparation for the critical take-off from the moon's surface. The descent stage will serve as a launching pad for the ascent stage and cabin. Once the two astronauts safely rendezvous with the orbiting command module and re-enter it, the ascent stage will be jettisoned. The ascent stage will be left in lunar orbit to relay information on the systems lifetime back to earth. Onboard guidance and navigation data, combined with deep-space tracking data transmitted from earth, will provide the crew with the references necessary to determine the return trajectory. The service module propulsion system will be used to escape from lunar orbit. Following a coasting period, the service module propulsion system will be ignited for the final time to perform any mid-course corrections required to place the command module into the correct re-entry corridor. The command module will come back into the earth's atmosphere at speed up to 36,000 feet a second. The returning astronauts will be aiming at a narrow re-entry corridor about 26 miles wide. This brief description of the plan for manned lunar landing and return outlines the basic mission profile, but greatly simplifies the painstaking procedures that will be observed to maximize crew safety and mission success.

CONTRACTOR INFORMATION

Command and Service Modules (CSM)

In December 1961, the Space and Information Systems Division of the North American Aviation Corporation, Downey, California, was selected as prime contractor to design, develop, and fabricate the command and service modules of the Apollo spacecraft. North American was also assigned responsibility for design and fabrication of the spacecraft/launch vehicle adapter; integration of test, scientific, and government-furnished equipment into the spacecraft; assembly and test of the spacecraft; and support of spacecraft preparation for flight. In addition to the work of North American as the prime contrator, funding in this line item includes the effort for development, procurement, integration, and installation of Apollo flight experiments and experimental hardware into the CSM.

The command and service modules are produced and checked out at North American's Downey plant and then shipped to various ground test locations or directly to the Kennedy Space Center for pre-launch preparations, including altitude chamber test runs in the Manned Spacecraft Operations Building. The adapter, which surrounds the lunar module and connects it with the command and service module, is built at North American's Tulsa, Oklahoma Division, as is some of the spacecraft ground support equipment.

Activity in FY 1968 will focus on manned command and service module flights on Uprated Saturn I vehicles to develop Apollo earth orbital rendezvous and docking techniques. Flight qualification of lunar-capable CSM will be emphasized on the Apollo Saturn V flights. Six Block II CSM are scheduled for delivery to the Kennedy Space Center in FY 1968. These spacecraft, plus the two delivered in late FY 1967, will undergo checkout in preparation for Uprated Saturn I and Saturn V flights. The remaining seven Block II CSM will be in various phases of assembly, systems installation, and in-plant checkout.

Lunar Module (LM)

Study and design effort for the lunar module was initiated by Grumman Aircraft Engineering Corporation, Bethpage, New York, in early 1963. The funding provides for the Grumman effort and related experiments and hardware that will be carried in the lunar module.

In FY 1968, a refurbished lunar module test article will be launched on a Saturn V earth orbital flight. Five lunar modules are scheduled to be delivered to the Kennedy Space Center, and the remaining seven will be undergoing structural assembly, subsystem installation and factory checkout.

Guidance and Navigation (G&N)

The guidance and navigation system units for the Apollo spacecraft were designed by the Massachusetts Institute of Technology. The General Motors/A.C. Electronics Division in Milwaukee, Wisconsin, is the prime contractor for fabricating the inertial guidance, including the associated electronics, ground support, and checkout systems, and for assembling and testing all components of the system. The onboard navigational computer is being manufactured by the Raytheon Company, Waltham, Massachusetts, under a subcontract; the optical subsystem, including a space sextant, sunfinders, and navigation display equipment, is being built by the Kollsman Instrument Corporation, Elmhurst, New York, also under a subcontract. An intensive ground test program, leading to system qualification and demonstration of reliability, will continue this year.

Integration

Integration, reliability, and checkout funding provides for the engineering support required for spacecraft specification maintenance and review; systems performance analysis; reliability and quality assurance; trend analysis of failure reports; critical parameter studies and technical problem analysis documentation; simulation and training; and interface control. Funding for FY 1968 continues this effort at a level consistent with the increased rate of hardware deliveries and frequency of Apollo missions.

This funding also provides for automatic checkout equipment (ACE) stations, including design, development, fabrication, installation and operation. The spacecraft ACE is used at the contractor plants and at NASA test and launch sites for separate and combined checkout of the spacecraft systems. The basic design of ACE ground stations for each of the major elements of the program was completed in FY 1964. Five stations became operational during FY 1965: three at North American Aviation; one at the Manned Spacecraft Center; and one at the Kennedy Space Center. During FY 1966, five more stations became operational: two at Grumman; two at the Kennedy Space Center; and one at the Manned Spacecraft Center. Two final stations, one at Grumman and one at the Kennedy Space Center, became operational in FY 1967. In FY 1968, funding provides for operation of all the stations, as well as related engineering changes and spare parts to maintain the operational equipment.

Spacecraft Support

Spacecraft support funds provide for the requirements for test operations, crew equipment including space suits, logistics, instrumentation, and scientific equipment.

Funds for test operations are required to conduct spacecraft development tests at the Manned Spacecraft Center, the White Sands Test Facility, and other government test laboratories. Testing at the Manned Spacecraft Center facilities includes unmanned and manned thermal-vacuum testing in the environmental test laboratory, docking simulation tests, component and subsystem qualification, reliability and verification testing, and electronic systems compatibility tests.

Spacecraft support funding also provides for development and procurement of spacesuits and related crew equipment, survival equipment, food, extravehicular activity umbilicals, personal hygiene systems, and bioinstrumentation. Major effort in FY 1968 relates to manufacture and test of a spacesuit and portable life support system, which is required on the lunar surface.

Logistic funding for FY 1968 is required for transportation of spacecraft between installations, reimbursement to the Department of Defense for inspection services, and procurement of spacecraft fuels and propellants used in the test programs at the Manned Spacecraft Center, the White Sands Test Facility, the Kennedy Space Center, the Arnold Engineering Development Center, and contractor sites.

Instrumentation and scientific equipment funding for FY 1968 provides for development and procurement of specialized flight research and test instrumentation for spacecraft development flight testing. Typical equipment includes signal conditioners, sensors, transmitters, antennas, ground support equipment, cameras, and radiation measuring devices.

Uprated Saturn I

	1966	1967	1968
1st stage (S-1B)	$51,580,000	$43,100,000	$30,500,000
2nd stage (S-IVB)	63,999,000	56,900,000	37,100,000
Instrument unit	47,660,000	40,600,000	22,600,000
Ground support equipment	26,575,000	11,500,000	6,500,000
H-1 engines	10,150,000	8,050,000	5,200,000
J-2 engines	13,500,000	6,716,000	900,000
Vehicle support	61,322,000	69,734,000	53,400,000
Total	$274,786,000	$236,600,000	$156,200,000

The Uprated Saturn I is an improved version of the original launch vehicle in this class - the Saturn I.

The two-stage Uprated Saturn I stands 142 feet tall, excluding the Apollo spacecraft, and has a diameter of 22 feet. The 1st stage is 80 feet high; the 2nd stage - 59 feet; and the instrument unit - 3 feet. The 1st stage, which is powered by eight H-1 engines yielding about

1.6 million pounds of thrust, is an uprated version of the 1st stage used successfully on the Saturn I. The 2nd stage, which has the same basic design as the 3rd stage of the Saturn V, is powered by a single hydrogen-fueled J-2 engine capable of over 200,000 pounds of thrust.

The Uprated Saturn I can place about 20 tons of payload into a low earth orbit and is used for unmanned, manned, long duration, and rendezvous flights in the development of the Apollo spacecraft. The Uprated Saturn I will be utilized for Apollo applications missions.

1st Stage (S-IB)

The Chrysler Corporation Space Division is producing, assembling, checking out, and testing the S-IB stages. Production, assembly, and initial checkout are conducted at the government-owned Michoud Assembly Facility near New Orleans, Louisiana. The stage is then barged to the Marshall Space Flight Center, Huntsville, Alabama, for static testing. After testing, the stage is returned to Michoud for post-static checkout. The completed stage is then shipped to the Kennedy Space Center for pre-launch checkout.

During FY 1968, the remaining five stages for Apollo Uprated Saturn I vehicles, which are currently phased into fabrication, assembly, and in-plant checkout, are scheduled for completion of acceptance testing, post-static checkout, and shipment to the Kennedy Space Center. Funds requested support delivery and pre-launch checkout of the eighth and ninth flight stages; acceptance test, and shipment of the tenth and eleventh stages to Kennedy Space Center; and final assembly, in-factory checkout, acceptance test, and delivery of the last stage. Also covered are specific stage support activities, which encompass electrical and flight data measuring equipment, as well as propellants and special test equipment required for acceptance firings. Field support services for ground and flight test evaluations of the stage are also included.

2nd Stage (S-IVB)

Basic development costs for this stage are funded in the Saturn V project. Procurement and engineering design effort and modifications to adapt the stage to Uprated Saturn I requirements are funded in this budget line item. The stage, which is produced by the Douglas Aircraft Company, Missiles and Space Division, has the same basic design as the S-IV used in the Saturn I series. However, a single J-2 engine developing about 200,000 pounds of thrust has replaced the six RL-10 engines yielding 90,000 pounds of thrust. The Uprated Saturn I provides early experience with the S-IVB stage, which will be used as the 3rd stage of the Saturn V. The S-IVB is manufactured, assembled, and checked out at the Douglas Huntington Beach, California, facilities. Hydrostatic tests to assess dynamic pressures are conducted at Huntington Beach. The flight stages undergo acceptance testing to verify performance specifications and launch readiness at the Sacramento Test Operations (SACTO) site.

The FY 1968 funding supports delivery of the last five S-IVB flight stages for Apollo to the Kennedy Space Center. The eighth and ninth will arrive at the Center and undergo pre-launch checkout; the tenth and eleventh will complete acceptance testing at Sacramento and will subsequently be shipped to the Kennedy Space Center. The twelfth flight stage is scheduled to be through assembly, in-plant checkout, acceptance testing, and poststatic checkout in preparation for shipment.

Instrument Unit (IU)

The instrument unit is the "nerve center" of the vehicle. It contains the all-important primary guidance, control, measuring, and telemetry systems which govern the engine gimballing, in-flight sequencing of the engine propulsion system, staging operations, and primary timing signals. These units are being assembled and tested by the International Business Machines Corporation in Huntsville, Alabama. The components and configuration are essentially the same as those used for the Saturn V.

Funding in FY 1968 supports completion of assembly and checkout, as well as delivery of the remaining five flight instrument units. In addition, the funds provide for IBM launch support at the Kennedy Space Center.

Ground Support Equipment (GSE)

The automatic ground support equipment used to checkout the Uprated Saturn I provides a transitional step to the even more complex procedures required for the Saturn V. This category includes electrical support equipment which is provided by the General Electric Corporation, and mechanical support equipment, which is provided by the Chrysler Corporation Space Division. Automatic ground checkout stations provide a means of protecting the investment in flight hardware and reducing the length of time and cost of manual checkout. Vehicle hardware is subjected to extensive checkout on the ground to verify systems reliability after assembly and static firing and during the pre-launch period at the Kennedy Space Center. In addition to these checkout stations, a GSE development system or breadboard is operated at the Marshall Space Flight Center to provide the capability to validate the computer programs used at the Kennedy Space Center. The basic computer is the RCA 110A.

The FY 1968 funds support operation and updating of stage and vehicle ground support equipment, including mechanical and electrical support equipment, to satisfy the specific mission requirements for the scheduled Uprated Saturn I launches. Included are the checkout operations for the stages, instrument units, and assembled launch vehicles used for the earth orbital and rendezvous missions planned during this period.

H-1 Engines

The H-1 engine, developed and produced by the Rocketdyne Division of North American Aviation Incorporated, is used in clusters of eight to propel the first stage of the Uprated Saturn I. Development of the H-1 engine was initiated by the Department of Defense in September 1958 as a 165,000 pound thrust, improved version of the Thor-Jupiter engine. The responsibility for development of the engine was transferred to NASA in 1960. The 165,000 pound thrust engine was used successfully in the first four Saturn I launches, and a 188,000 pound thrust version of the engine was used on the remaining six Saturn I vehicles. The thrust of each liquid oxygen/kerosene H-1 was increased to 200,000 pounds for the Apollo Saturn 201 through 205. Beginning with the Apollo Saturn 206 mission, the thrust capability will be increased to 205,000 pounds per engine.

Funds for FY 1968 will provide for continued support of the flight program and for evaluation of flight data for use in subsequent missions.

J-2 Engines

The J-2 engine, which was developed and produced by the Rocketdyne Division of North American Aviation, is used in the upper stages of both the Uprated Saturn I and the Saturn V. A single J-2 is used in the 2nd stage of the Uprated Saturn I. This version of the J-2 engine utilizes liquid hydrogen and liquid oxygen as propellants and delivers up to 200,000 pounds of thrust.

In FY 1968, funds will cover J-2 field support, which provides for rapid response to any problems encountered in the flight series.

Vehicle Support

Vehicle support includes funds for studies, services, and equipment common to more than one stage of the Uprated Saturn I. Funding provides for engineering services; reliability tests; fabrication services; transportation; propellants; expendable supplies and equipment; and launch pad refurbishment. This funding also covers contract administration, audit, quality assurance and inspection services performed on a reimbursable basis by the Department of Defense.

During FY 1968, heavy emphasis will be placed on pre-launch and launch support at the Kennedy Space Center in preparation for highly complex dual launches from Complexes No. 34 and No. 37. The ability of the complete launch vehicle to function as an integrated, reliable system will be validated on the ground before the precision timed dual launches are attempted. Activities will include component and subsystem testing, analysis and correction of pre-launch problems, incorporation of flight data into reliability assessments, and development of an integrated reliability report for each mission. Guidance and control system studies will be conducted. In addition, the requirements cover refurbishment of the launch pad in preparation for the next mission. The FY 1968 vehicle support funds also include transportation of the flight stages and instrument units. Barges, sea-going vessels, and specially designed aircraft are used to carry the outsize stages and components.

Saturn V

	1966	1967	1968
1st stage (S-1C)	$191,906,000	$184,900,000	$174,700,000
2nd stage (S-II)	256,164,000	248,600,000	245,900,000
3rd stage (S-IVB)	162,016,000	154,000,000	151,200,000
Instrument unit	67,760,000	72,900,000	75,100,000
Ground support equipment	107,572,000	60,900,000	35,800,000
F-1 engines	66,200,000	92,307,000	105,300,000
J-2 engines	67,200,000	83,493,000	78,500,000
Vehicle support	216,053,000	238,500,000	242,000,000
Total	$1,134,871,000	$1,135,600,000	$1,108,500,000

The Saturn V, which is the most powerful member of the Saturn family of launch vehicles, is composed of three propulsion stages and an instrument unit. This vehicle is designed to boost payloads up to 140 tons into a low earth orbit and to accelerate payloads up to 48 tons to the seven-mile-a-second velocity required to escape the earth's gravitational field and accomplish lunar or deep space missions. In its present configuration, the vehicle will provide a broad capability for manned space operations. Development of the versatile Saturn V began in January 1962 when management responsibility was assigned to the Marshall Space Flight Center. The decision to develop this version of the Saturn class vehicles was preceded by exhaustive studies on the most feasible configuration for a large launch vehicle with high performance and payload capability for earth orbital and lunar missions.

The physical characteristics of the Saturn V are as impressive as its mission. The assembled launch vehicle is 282 feet high. The 1st and 2nd stages (S-IC and S-II) measure 33 feet in diameter and stand, respectively, 138 and 82 feet high; the 3rd stage (S-IVB) is 22 feet in diameter and 59 feet high; and the instrument unit is three feet high. At lift-off, the Saturn V will weigh 6 million pounds. As an indication of the booster power, the Saturn V 1st stage yields about 7.5 million pounds of thrust in comparison with the 1.6 million pounds generated by the 1st stage of its predecessor, the Uprated Saturn I.

The Saturn V schedule provides for fifteen launch vehicles in support of Apollo unmanned qualification flights, manned lunar mission simulations, and manned lunar missions. Saturn V hardware production and deliveries are rapidly building up to meet the mission requirements. Peak production activity, based on hardware in process, will be reached during 1967. Work is already underway on all the fifteen Saturn V launch vehicles. Manufacture of the first five has been completed and long leadtime components for the last launch vehicles are being fabricated. By the end of the year, assembly of the fifteenth launch vehicle will be underway.

1st Stage (S-IC)

The Saturn V 1st stage, which generates approximately 7.5 million pounds of thrust, is the most powerful developed by this country to date. The stage is powered by five liquid oxygen-kerosene F-1 engines, each developing about 1.5 million pounds of thrust. This large cylindrical stage is 138 feet high and 33 feet in diameter; its dry weight is approximately 290,000 pounds. The fuel tank has a capacity of 210,000 gallons of RP-1 (kerosene), while the oxidizer tank can hold 327,000 gallons of liquid oxygen. At launch, the S-IC will be lifting a total space vehicle weight of six million pounds. During flight the stage burns for two and a half minutes, consuming about 15 tons of propellant a second.

Development began in early 1962. The Marshall Space Flight Center, with the assistance of the Boeing Corporation, manufactured the structural test components, the first ground test stage, and the first two flight stages at Huntsville, Alabama. Manufacturing of the first flight stage began at Huntsville in July, 1964. Boeing was awarded the contract to manufacture two other ground test stages (dynamic and facilities checkout) and thirteen flight stages at the government-owned Michoud Assembly Facility near New Orleans, Louisiana.

The FY 1968 funds support completion of the S-IC structural test program and continuation of assembly, in-plant checkout, acceptance testing, and shipment of flight stages to the Kennedy Space Center. The fourth, fifth, and sixth stages will be put through post-static checkout at Michoud, delivered to the Kennedy Space Center, and prepared for flight. The seventh and eighth 1st stages are scheduled to complete assembly, in-plant checkout, and static testing; and the ninth and tenth are scheduled to be through manufacturing and checkout at Michoud. The five remaining stages are planned to be in manufacturing during FY 1968.

2nd Stage (S-II)

The 2nd stage of the Saturn V is powered by a cluster of five liquid oxygen-liquid hydrogen J-2 engines, producing a total thrust of approximately 1 million pounds at altitude. It is the Nation's largest liquid-hydrogen powered stage. The cylindrical stage is approximately 82 feet high and 33 feet in diameter. The aluminum alloy skin on the initial stages is only .153 inches thick and will be reduced to .128 inches in subsequent stages. The structure contains two propellant tanks separated by an insulated common bulkhead. The top tank holds almost 290,000 gallons of liquid hydrogen; the lower tank, located below the common bulkhead, holds almost 94,000 gallons of liquid oxygen. Starting off on the launch pad, its gross weight, including engines, is about one million pounds - 90% of which consists of propellants. During flight the stage burns for six and a half minutes and withstands temperatures ranging from about +400 to -400 degrees Fahrenheit. The component qualification requirements for the S-II are particularly stringent because the stage stretches to the utmost existing hydrogen propulsion technology and related manufacturing techniques.

Design, production, and ground test of this stage are performed by the North American Aviation Space and Informations Systems Division. Manufacturing, assembly, and factory checkout are accomplished at government-owned facilities at Seal Beach, California. North American conducts developmental ground testing at its Santa Susana Static Test Laboratory. Flight stages are shipped through the Panama Canal to the Mississippi Test Facility to undergo acceptance firing before being delivered to the Kennedy Space Center.

Fiscal year 1968 activity will continue to emphasize production of hardware in support of the Apollo Saturn V flight requirements. The third, fourth, fifth, and sixth flight stages are scheduled for completion of acceptance test, post-static checkout, and shipment to the Kennedy Space Center. Exhaustive pre-launch checkout procedures will be conducted at Kennedy to assure that these stages measure up to the stringent performance standards established for manned flight.

3rd Stage (S-IVB)

Basic development cost for this stage, which is also used on the Uprated Saturn I, are funded in this line item. The S-IVB is being developed, produced, and tested by the Douglas Aircraft Company, Missile and Space Systems Division, which also produced the upper stage of the Uprated Saturn I. The stages are manufactured and tested at the Douglas Space Center, Huntington Beach, California, and acceptance testing is conducted at the Sacramento Test Operations Site.

Fiscal year 1968 activity will focus on continued production and delivery of flight stages to support the Apollo Saturn V schedule. The fourth flight stage will be shipped from the West Coast to the Kennedy Space Center for pre-launch checkout. The next two flight stages are scheduled to be through fabrication and in-plant checkout at Huntington Beach, as well as acceptance testing and post-static checkout at the Sacramento Test Operations Site; these stages are also scheduled for delivery to the Kennedy Space Center by the end of FY 1968. Fabrication, assembly, in-plant checkout, and acceptance testing of the seventh and eighth flight stages are planned, and the ninth and tenth will be through fabrication and assembly in preparation for acceptance firing at Sacramento. The remaining five stages will be in various phases of manufacture and assembly.

Instrument Unit (IU)

Fiscal year 1968 will be marked by a steady delivery rate in support of the scheduled Apollo Saturn V missions.

Ground Support Equipment (GSE)

The Saturn V ground support equipment consists of electrical and mechanical support equipment required to test and check out the stages, instrument units and associated hardware. Automatic checkout equipment is used at the manufacturing, static test, and launch sites.

The General Electric Company is under contract for design, fabrication, checkout, and logistic support of the Saturn V electrical support equipment. The Boeing Company is contractor for a Saturn V equipment management system, which provides a master record for all vehicle ground support equipment. Boeing is also responsible for the integration and logistic support of all mechanical support equipment. The Radio Corporation of America is providing the computer systems and Sanders Associates the display systems for use at Launch Complex No. 39.

Funds in FY 1968 support preparation and verification of computer tapes for the manned Saturn V missions and also provide for completion of Saturn V - related GSE for the third launch umbilical tower, high-bay, and firing room at Launch Complex No. 39.

F-1 Engines

The F-1 engine is being developed and produced by North American Aviation/Rocketdyne Division at Canoga Park, California. Engine testing is conducted at Edwards Air Force Base, California. Five liquid oxygen/ kerosene F-1 engines are clustered in the first stage of the Saturn V.

Each engine generates approximately 1.5 million pounds of thrust, for a total thrust of approximately 7.5 million pounds.

Funds in FY 1968 provide for continued engine deliveries to meet flight requirements. Thirty-four F-1 engines are scheduled for delivery during this period. The funds also cover quick response to any F-1 problems encountered in the flight missions.

J-2 Engines

The J-2, which was developed and is being produced by North American Aviation, Rocketdyne Division, is used in the two upper stages of the Saturn V. The second stage is powered by five J-2 engines, each producing over 200,000 pounds of thrust. The third stage is powered by a single J-2 engine with restart capability.

The funds in FY 1968 will provide for delivery of 36 more engines and for rapid response to any problems encountered during the Saturn V flights.

Vehicle Support

Vehicle support funds are required to provide services and equipment that are common to more than one stage of the vehicle. In FY 1968, emphasis will be placed on static test activities at the Mississippi Test Facility and vehicle support at the Kennedy Space Center. Systems integration will continue to insure proper interface control of all stages, systems, and structures and reliability and flight evaluation programs will also be funded.

Engine Development

	1966	1967	1968
Engine development	$133,200,000	$49,800,000	$24,500,000
Total	$133,200,000	$49,800,000	$24,500,000

Development effort on the family of engines used in the Saturn launch vehicles was initiated in September, 1958, by the Department of Defense under a contract with the Rocketdyne Division of North American Aviation to develop an improved version of the Thor-Jupiter engine.

During FY 1968, the funds requested will provide for government-furnished propellants, reimbursement to the Department of Defense for contract administration and quality assurance services, and a continuing program of government in-house and independent contractor evaluation and analysis of prime contractor-produced hardware. The major activity in this area is the J-2 engine environmental test program conducted at the Air Force Arnold Engineering Development Center, Tullahoma, Tennessee. Other activities include operating limits investigation, materials investigation, and quality and reliability studies. The total evaluation and analysis program is directed toward identification of those materials and components which have the greatest operational restrictions or least confidence. Improvements, which will result in a launch vehicle of greater operational flexibility, reliability, or safety, are then incorporated into the engines.

Mission Support

	1966	1967	1968
Operations	$112,928,000	$196,900,000	$229,000,000
Systems engineering	20,000,000	20,000,000	20,000,000
Supporting development	31,400,000	27,000,000	32,000,000
Total	$164,328,000	$243,900,000	$281,000,000

Mission support provides for the over-all launch, flight, crew and recovery operations; program-wide systems engineering; and supporting development necessary for the successful accomplishment of manned space flights.

Operations

Operations include those activities at the Kennedy Space Center and the Manned Spacecraft Center directly concerned with the launch and flight of Apollo missions. Funding for the Kennedy Space Center covers the operation of checkout, launch, and instrumentation facilities. These requirements also provide for contractor services, equipment and supplies, and reimbursement for services performed by the Air Force. At the Manned Spacecraft Center, activity includes mission control for Apollo flights; support of astronaut training and flight crew requirements; operation and updating of mission simulation; mission planning and analysis; contractual development of real-time computer programs for flight missions and flight monitoring; remote site operations; and recovery equipment and activities, including reimbursement to the Department of Defense for recovery operations.

The increase in the FY 1968 fund requirements is directly related to the increase in the Apollo flight rate. At the Kennedy Space Center, the contractor effort for launch instrumentation and operational support of launch activities, and at the Manned Spacecraft Center, the contractor effort for operational support of the mission control center, will increase directly in relation to the number of flights planned.

Systems Engineering

Systems engineering provides for integrated technical support, review, and analysis of manned space flight missions. These services include the development of functional and performance standards for the program, consistent with mission objectives; mission planning; test objectives and integration; program and systems specifications; trajectory analysis; checkout effectiveness; and technical documentation. Bellcomm and General Electric are the principal systems engineering contractors.

The systems engineering requisite for trajectory analysis, checkout effectiveness, analysis of flight mission results, detailed studies of specific lunar landing areas and constraints, and technical documentation will continue through FY 1968 to support the increased flight activity.

Supporting Development

Supporting development is a continuing program which involves individually selected engineering efforts to eliminate potential deficiencies in on-going programs and to provide a firm base for hardware decisions pertinent to extension of the program. The end objectives are to remove identified deficiencies, and to provide backup solutions where required. Supporting development also covers development of improved hardware or manufacturing, test, and evaluation techniques to reduce cost and to upgrade performance and confidence. In addition, supporting development includes the identification of marginal components, systems or techniques and the development of modifications that could also be used in new projects. The character of the work varies with each work unit, depending on the state of development of the hardware or technique, and is strongly influenced by the nature of the mainstream program problems or long leadtime system requirements for program modifications or extensions. In some cases, the potential problem may best be overcome by developing new hardware or techniques; and, in other cases, by modification of the mainstream approaches through better definition of specifications.

Work initiated during previous years is providing developed hardware during FY 1967.

The supporting development requirements remain substantially constant to provide for the solution of potential Apollo mainstream deficiencies. These solutions will also be incorporated into the development of hardware and techniques associated with probable new projects. The supporting development efforts will be concentrated largely in the S-II stage area and tasks related to the Apollo spacecraft. In the S-II stage area, continued work to develop alternate approaches to the difficult fabrication techniques is considered essential. In the Apollo spacecraft area, there are still some remaining materials compatibility problems, and a requirement to provide for the possibility of additional on board data storage.

In the long leadtime development area, increased effort is planned to investigate the exploitation of the inherent capabilities of the current Apollo/Saturn systems and facilities. Application of these capabilities for long term low and synchronous earth orbital and extended lunar effort will require such tasks as development of multiple restart capability for upper stages, improved insulation for propellant storage in space, and improved guidance and navigation systems.

OFFICE OF SPACE SCIENCE AND APPLICATIONS

PHYSICS AND ASTRONOMY PROGRAM

Program Objectives:

The objective of the Physics and Astronomy program is to increase our knowledge of the space environment of the earth; of the sun and the relationship of the sun to the earth and to the interplanetary medium; and of the fundamental physical nature of the universe. In order to achieve this objective, research programs have been developed to study the upper atmosphere, the ionosphere, the earth's magnetosphere, the region beyond the boundaries of the magnetosphere, solar radiation, the solar wind particles and its interactions in space, cosmic rays from beyond the solar system, and radiation from stars and other celestial bodies which cannot be observed from the earth's surface.

Resources Required:

	(Thousands of Dollars)		
	1966	1967	1968
Supporting research and technology/Advanced studies	$20,594	$19,900	$19,900
Solar observatories	19,052	9,800	11,900
Astronomical observatories	22,300	27,700	40,600
Geophysical observatories	28,215	24,000	20,000
Pioneer	12,700	7,200	7,500
Explorers	18,592	19,200	21,600
Sounding rockets	19,300	20,000	22,000
Sunblazer	---	---	2,000
Data analysis	2,000	2,000	2,000
Total	$142,753	$129,800	$147,500

FUNDS REQUIRED:

Supporting Research and Technology

The objectives of the Supporting Research and Technology project are to provide a sound theoretical base for the flight programs; to initiate development of instrumentation for future experiments; to provide laboratory data for evaluation of flight data; to conduct balloon and aircraft observations for correlation with flight program results; and to provide scientific support for the manned space flight program.

Advanced Studies

Advanced Studies establish the concepts, characteristics, and feasibility of future manned and automated earth-orbital and interplanetary missions. Among the missions to be studied are small scientific satellites of the Explorer class, specialized Explorers, galactic - Jupiter probes, and small interplanetary probes.

Solar Observatories

The objective of the Orbiting Solar Observatory (OSO) project is advancement of solar physics through the use of space techniques which permit expansion of solar research by elimination of the atmospheric absorption which occurs with ground-based observations. The solar observatories are designed to provide an investigation of the sun and of its changing activities.

Fiscal year 1968 funds will provide for completion and launch of the sixth observatory; for continuing work on the two follow-on spacecraft and experimental packages; and for data analysis on the fourth, fifth, and sixth observatories.

Astronomical Observatories

The primary objective of the Orbiting Astronomical Observatory (OAO) project is to provide a precisely stabilized observatory above the atmosphere to observe the universe.

Fiscal year 1968 funds will provide for the integration of the experiments and observatory tests for the prototype and the OAO-A_2 mission, the initiation of launch preparations for OAO-A_2, and acceptance tests for the OAO-B experiment. Funds will also be used for the development, fabrication and test of the OAO-B and OAO-C spacecraft and for the construction of the flight hardware for the Princeton experiment on OAO-C.

Geophysical Observatories

The objective of the Orbiting Geophysical Observatory (OGO) project is to develop a standard earth-orbiting observatory capable of carrying large numbers of experiments in a wide variety of orbits to investigate simultaneously geophysical phenomena and their interrelationships with solar activity, the interplanetary and galactic medium, the terrestrial magnetosphere, and the atmosphere.

Fiscal year 1968 funds are for completion and launch of OGO-E and integration and test of OGO-F. They will also provide for completion of first run data analyses for OGO-I and II, continuation of data analysis for OGO-II; initiation of data analysis for OGO-D and E; and completion of OGO-F experiment hardware fabrication.

Pioneer

Pioneers are investigating the interplanetary environment and the propagation of solar and galactic phenomena through this medium. Data from the two Pioneers and similar measurements made near earth provide simultaneous observations at widely separated points in space.

Funds requested for FY 1968 will continue to support the post-launch operations for Pioneer VI and VII, final testing and launch of the third spacecraft, and initial integration and testing for the fourth spacecraft.

Explorers

The Explorer class of satellites has been one of the most efficient and economical means of accomplishing a variety of scientific missions. A substantial portion of the scientific data gathered and many new discoveries are attributable to instruments carried in Explorer spacecraft. These spacecraft, most of which are launched by the relatively inexpensive Scout and Delta vehicles, are specifically designed for particular scientific investigations, and are flown in orbits suitable for these investigations.

These spacecraft are developed by NASA installations, industry, universities, and cooperating foreign countries. Many smaller organizations have been able to gain competence and experience by participating in the development of these small Explorer spacecraft. Fiscal year 1968 funds provide for an essentially level-of-effort program, with initiation of follow-on missions emphasizing radio and X-ray astronomy.

Sounding Rockets

Sounding rockets are the most effective means of making scientific studies of the upper atmosphere at altitudes above 20 miles and below perigee altitudes of earth satellites. These rockets are relatively small, inexpensive vehicles capable of carrying wide varieties of instrumentation for studies related to the atmosphere, the ionosphere, energetic particles, astronomy, and solar physics.

The small increase in the funding requirements requested for the Sounding Rocket program in FY 1967 and FY 1968 is largely due to the development and increased use of improved attitude control systems; and to the increased use of larger, more expensive vehicles to carry stabilized heavier payloads.

Sunblazer

The basic objective of the Sunblazer project is to place small, relatively inexpensive scientific spacecraft into heliocentric orbits to study the solar corona. This is to be accomplished by means of a propagation experiment, magnetic field mapping and observations of solar particle fluxes. Fiscal year 1968 funds will initiate the procurement of components, fabrication and assembly, integration, test, and preparation for launch of Sunblazer A. Experiment funding will allow for the pre-launch formating and programming of the propagation experiment.

Data Analysis

The primary objective of this project is to carry out NASA's obligation to make the scientific information gained from space projects available to the public. Data accumulated from NASA's earth orbiting spacecraft, sounding rockets, and space probes are being reduced and placed in storage at the National Space Science Data Center located at the Goddard Space Flight Center. Here it is catalogued and distributed to interested researchers. Fiscal year 1967 and FY 1968 funds provide for the operation of the Data Center and for the support of research tasks utilizing the data stored there.

OFFICE OF SPACE SCIENCE AND APPLICATIONS

LUNAR AND PLANETARY EXPLORATION PROGRAM

Program Objectives:

The Lunar and Planetary Exploration program carries out the scientific exploration of the solar system by means of earth-based research and automated spacecraft. The immediate objectives are the exploration of the moon, the planets Mars and Venus, and the interplanetary space between. Long range objectives include eventual explorations of Mercury, the outer planets and their moons, comets, asteroids, and the interplanetary medium enroute to these bodies.

Resources Required:
(Thousands of Dollars)

	1966	1967	1968
Supporting research and technology	$23,000	$20,900	$20,900
Surveyor	104,634	84,500	42,200
Lunar orbiter	58,081	28,800	10,000
Mariner	17,585	35,200	68,900
Ranger	1,000	---	---
Total	$204,300	$169,400	$142,000

Funds Required:

Supporting Research and Technology

This program will carry out work not specifically a part of currently approved flight missions, but which contributes to lunar and planetary science, advanced technical development, or advanced mission planning. Ground-based observation and measurements of extraterrestrial bodies provide basic scientific data to be used in comparison with flight measurements. This program also provides early funding for promising experiments which may later be selected for flight missions and provides for work to advance technology as required for future missions, including current work on spacecraft sterilization for the prevention of planetary contamination by terrestrial organisms. Advanced studies funded by this program define future mission possibilities to satisfy various scientific objectives.

Surveyor

The objectives of the Surveyor project are to develop the technology required to accomplish successful soft landings at predetermined sites on the moon and to conduct scientific measurements on the lunar surface. The funds requested for FY 1968 will complete assembly, systems environmental and flight acceptance tests, launch and post-launch operations for the last of the seven Surveyor spacecraft.

Lunar Orbiter

The Lunar Orbiter teams with the soft landing Surveyor to provide detailed information about the lunar surface. The five spacecraft in the program serve as orbiting platforms to photograph in detail extended areas of the moon to be used to select suitable Apollo landing sites. Orbiters I and II have returned high (one meter) resolution pictures of 13 candidate Apollo landing sites covering an area of 4,000 square miles and wide angle (8 meter) resolution pictures of 22 candidate Apollo landing sites covering an area of 30,000 square miles. The funds requested for FY 1968 will provide for the acceptance testing of the remaining three Lunar Orbiter spacecraft, launch and mission operations, and data analysis.

Mariner

The Mariner project conducts the early exploration of the planets with automated spacecraft in the 400 to 1,200 pound class, and will provide the scientific and technological basis for detailed exploration by spacecraft of the Voyager class. A modified Mariner IV spacecraft will look at Venus in October 1967, searching for the presence of hydrogen and oxygen and obtaining atmospheric profile data in addition to data on magnetic fields and charged particle and micrometeoroid flux. The Mariner-Mars 1969 fly-by is designed to improve on the results of Mariner-IV, which first photographed the cratered surface of Mars, by examining the spectrum of the planet in the infrared and ultraviolet in addition to providing better television pictures than the 1,500 meter resolution obtained by Mariner IV. The mission planned for the 1971 Mars opportunity will use the same basic design as the 1969 spacecraft, with the modifications required to obtain higher resolution pictures of the surface and to probe the Martian atmosphere with a scaled down Voyager capsule, which would telemeter qualitative data on atmospheric constituents and structure as it descends through the atmosphere. These data will aid in optimizing the 1973 Voyager mission profile. The FY 1968 funds requested will provide for the Mariner-Venus 1967 post-launch operations as the spacecraft is enroute to the planet, the encounter operations, and data analysis; provide for Mariner-Mars 1969 flight hardware, initiate assembly of the flight spacecraft and finish type approval tests of prototype subsystems and environmental systems test of the prototype spacecraft; and fund the Mariner-Mars 1971 effort through the establishment of functional specifications and completion of systems design, including testing of prototypes of critical subsystems.

OFFICE OF SPACE SCIENCE AND APPLICATIONS

VOYAGER PROGRAM

Program Objectives:

The Voyager is a major new program for which full-scale design and development will start in FY 1968. The Voyager will provide the first opportunity for man to obtain sufficiently detailed data to permit a significant step in the understanding of the planets and the application of this information to the earth itself.

Three primary objectives will shape the Voyager missions: To gain knowledge about the origin of the solar system, to gain knowledge about the origin of life, and to apply both to a better understanding of terrestrial life.

The objectives are being used to define the Voyager mission requirements. The Voyager capability will far exceed that of the Mariners and represents a major forward step in this country's planetary exploration program. The Saturn V, developed for Apollo, will be used as the Voyager launch vehicle.

In persuit of these goals, beginning with the 1973 Mars opportunity, Voyager will orbit, and soft land on the planet and search for evidence of forms of life. The first Voyager mission will provide data on the physical, thermal, and chemical properties of the planet, transmit to earth high resolution photographs of Mars' surface. It is planned to design the Voyager spacecraft so that many of its basic systems, such as the spacecraft, can be used with a minimum of modification for exploration to planets other than Mars. This would minimize development costs for possible future planetary missions, such as landing on Venus, which are currently being studied.

Resources Required:

	(Thousands of Dollars)		
	1966	1967	1968
Voyager	$17,097	$10,450	$71,500
Total	$17,097	$10,450	$71,500

Funds Required:

Initially, Voyager will investigate the closest planets, beginning with Mars. The first flight missions are planned for Mars during the 1973 and 1975 opportunities. The Voyager will place an automated spacecraft in orbit and soft land an automated laboratory on the surface of Mars. One Saturn V launch vehicle will carry two Voyager planetary vehicles mounted in tandem at each of the two launch opportunities. Each planetary vehicle consists of a spacecraft and a landing capsule. The spacecraft will accomplish the transit to Mars, deliver the capsule into orbit, and conduct scientific observations of Mars from orbit over a period of several months. The landing package includes a capsule bus system and a surface laboratory system. The landed surface laboratory system will include instruments to study the chemistry of the atmosphere and surface; measure radiation, temperature, and seismic activity; and search for evidence of extraterrestrial life to the maximum extent possible on the early Voyager missions.

It is anticipated that changes will be made to the surface laboratory from mission to mission as the scientific understanding of Mars is increased. As this progression occurs, it is expected that adaptive and reprogrammable experiments will be conducted and the surface laboratory will evolve into the Voyager Biological Laboratory (VBL). The VBL concept is based upon the conviction that a flexible scientific laboratory type spacecraft will be required to provide results capable of unambiguous interpretation. The VBL will contain a reprogrammable computer capable of controlling and commanding its own operations based on data feedback from previous experiments, or by command from earth.

During FY 1968, system design and development will be initiated for the spacecraft, capsule bus, and surface laboratory systems. A single prime contractor will be chosen for each of the three systems to initiate final system design and to begin the development of long leadtime subsystems. In addition, it is expected that advanced development of scientific instruments which are candidates for the 1973 mission will be conducted in FY 1968. These will include visual imaging devices, mass spectrometer/gas chromatograph, various types of spectrometers, and life detection instruments.

During FY 1968, the VBL and its objectives will be defined in detail. The scientific community will be actively involved in this definition. In addition, subsystem design of the VBL will be initiated including breadboarding of critical subsystems.

During FY 1968 development of the launch vehicle nose fairing and shroud required for the Voyager missions will be continued. In addition, studies of Voyager launch criteria and planning of mission operations will be continued.

OFFICE OF SPACE SCIENCE AND APPLICATIONS

SUSTAINING UNIVERSITY PROGRAM

Program Objectives:

NASA depends upon universities to conduct portions of the basic research in support of the space program. To improve this support, the universities are strengthened by the Sustaining University Program. The Sustaining University Program encourages the universities by supporting graduate students in space-related disciplines. It also assists universities in the acquisition of facilities suitable for the effective conduct of space research. Its accomplishments contribute to the replenishment of the national supply of highly trained manpower, to an increase in the scope of research leading to advances in fundamental knowledge, and to improvement of the physical facilities for the conduct of both training and graduate research at universities.

Resources Required:

	(Thousands of Dollars)		
	1966	1967	1968
Training	$25,290	$16,000	$7,000
Research	12,860	11,000	10,000
Research facilities	7,850	4,000	3,000
Total	$46,000	$31,000	$20,000

LAUNCH VEHICLE DEVELOPMENT PROGRAM

Program Objectives:

The objective of the Launch Vehicle Development program is to provide a launch vehicle capability for automated mission requirements in a timely and economical manner. During FY 1966 and FY 1967, the program consisted of Advanced Studies, Supporting Research and Technology, and Centaur Development. With the completion of the Centaur Development Program during FY 1967, support for the on-going Advanced Studies and Supporting Research and Technology efforts is being requested under Launch Vehicle Procurement.

Resources Required:

	(Thousands of Dollars)		
	1966	1967	1968
Supporting research and technology/advanced studies	$4,000	$4,000	---
Centaur development	53,790	27,200	---
Total	$57,790	$31,200	---

LAUNCH VEHICLE PROCUREMENT PROGRAM

Program Objectives:

The objective of the Launch Vehicle Procurement program is to provide launch vehicles together with their related equipment and services in a timely and economical manner for the support of automated space flight missions and to provide minor development effort required in support of future mission requirements. In pursuit of this objective, the program includes a broad spectrum of development and procurement activity, including studies of future mission requirements and the technical developments required to successfully accomplish them, procurement of operational vehicle hardware, and the necessary supporting equipment and services. The Launch Vehicle Procurement program is presented as a separate program, but vehicle funding requirements related to specific flight projects are also shown as a parenthetical notation with the applicable project in order to provide a total estimate of project requirements. The operational vehicles currently procured are: Scout, Delta, Thor Agena, Atlas Agena, and Centaur.

Resources Required:

	(Thousands of Dollars) 1966	1967	1968
Supporting Research and Technology/Advanced Studies	---	---	$4,000
Scout	$11,700	$9,400	16,800
Delta	27,729	20,900	32,600
Agena	70,669	37,100	24,700
Centaur	65,000	55,000	87,000
Atlas	3,602	---	---
Total	$178,700	$122,400	$165,100

Funds Required:

Supporting Research and Technology/Advanced Studies

This project, previously funded under the Launch Vehicle Development program, has as its purpose to define vehicle requirements for future missions, to establish the methods by which performance in excess of current capabilities can be developed, and to develop and demonstrate new technology and techniques for meeting future requirements.

The FY 1968 funds will also be utilized for various investigations including an examination of the capabilities and limitations of strapdown guidance systems.

Scout Procurement

The FY 1968 funds for Scout procurement will be utilized to continue the current Scout vehicle and systems management contracts. Funds will also be required for sustaining engineering and maintenance, launch services, logistics requirements, and vehicle adaptation to meet individual mission specifications.

Delta Procurement

FY 1968 funds will be utilized to incrementally fund the procurement of Delta second stages, the procurement of THORAD boosters, and the procurement of third stage motors. In addition, funds will also be needed for launch services at the Eastern and Western Test Ranges. FY 1968 Sustaining Engineering and Maintenance funds will also be required for the TE-364 (Surveyor retro-motor), THORAD, and other engineering and maintenance activities.

Agena Procurement

FY 1968 funds will provide for continued procurement of the basic Agena vehicle in addition to the Thor and Atlas boosters. Funds will be utilized to adapt the basic Agena vehicle to various individual mission requirements. FY 1968 funds will also be needed for launch support requirements and Sustaining Engineering and Maintenance.

Centaur Procurement

The FY 1968 budget will be used to fund supporting services. FY 1968 funds will also be utilized to provide vehicle hardware and other supporting services for later launches of the Orbiting Astronomical Observatory, Applications Technology Satellite, Mariner Mars 1969 and Surveyor. Funds will also be required for Sustaining Engineering and Maintenance.

BIOSCIENCE PROGRAM

Program Objectives:

The Bioscience program has two principal objectives. The first is the search for extraterrestrial life with primary emphasis directed to Mars. This objective involves research intended to determine if the Martian surface provides a possible environment for life; whether life in some form exists, and if so, its characteristics; and if no life exists on Mars evaluate, by analytic study of evidence of chemical evolution, the probability of its previous or future occurrence. A planetary quarantine program is in operation to minimize the possibility that terrestrial organisms could contaminate Mars. The Voyager spacecraft will provide the first capability for landing a sterilized scientific package on the surface of Mars.

The second objective is directed towards attaining a thorough understanding of the effects of the space environment on terrestrial organisms.

Its implementation includes ground-based experiments, the Biosatellite project, and development of flight experiments for other missions.

Resources Required:

	(Thousands of Dollars)		
	1966	1967	1968
Supporting research and technology	$11,100	$11,550	$14,300
Biosatellite	23,300	30,000	30,000
Total	$34,400	$41,550	$44,300

Funds Required:

Supporting Research and Technology

The Exobiology program in pursuit of the search for extraterrestrial life conducts ground-based analytical studies of the origin of life on earth. This research ranges from the analysis of fossil remains, and simulation studies of Jupiter's atmosphere, to the development of automated life detection equipment intended to increase the reliability of the data by broadening the analysis of individual samples.

Research in Environmental Biology is concerned with the response or interaction of living earth systems with the variables of the space environment, including such space flight factors as weightlessness, acceleration, vibration, radiation and magnetism.

Emphasis in Behavioral Biology has been placed on the capacity of organisms to adjust to alternations in gravity, particularly the determination of responsiveness of gravity receptors to transient and prolonged stimulation.

The Physical Biology program supports research in comparative physiology, bio-instrumentation, and molecular biology. Research in comparative physiology includes studies on living organisms which specifically lend themselves to investigations in orbiting biological vehicles on the nutritional requirements of living organisms for prolonged space travel, and on the phenomena and dynamics of various physiological and behavioral systems.

The Planetary Quarantine program seeks to develop methods whereby terrestrial organisms will not be transported to the planets prior to thorough exploration with life detection payloads.

Biosatellite

The first Biosatellite was successfully launched on 14 December 1966.

Future Biosatellite flights will result in data which will have a wide range of applicability. The testing of biological hypotheses in the areas of genetics, developmental biology, environmental physiology, and general metabolism will be one result of these flights. The Biosatellite should also provide valuable data pertaining to biological requirements for prolonged manned space flight, and the possibility of delayed effects appearing in later life or subsequent generations of animal subjects, with possible applications to man. Also, these flights should result in the development and test of new instrumentation techniques, surgical preparations, and other procedures and devices which may have medical and other applications to human beings.

SPACE APPLICATIONS PROGRAM

Program Objectives:

This program combines the Communications and Applications Technology Satellites and Meteorological Satellites program which were shown separately in the FY 1967 and prior budgets. It also includes the Geodetic Explorers project, which was previously funded under the Physics and Astronomy program. The Meteorological Flight Experiments project, previously identified separately is now made a part of the appropriate Space Applications flight project.

The objectives of the Space Applications Program are to: (1) develop a capability to expand human knowledge of the phenomena in the atmosphere and space, and support the exploration of space, by conducting a broad-based program of applications-oriented research and technology development (National Aeronautics and Space Act of 1958), (2) develop and test procedures, instruments, subsystems, spacecraft, and interpretive techniques in the various applications areas, (3) accomplish long-range studies of the potential benefits to be gained from, and the problems involved in, utilization of space activities for peaceful and technological purposes for the benefits of mankind, (4) fulfill NASA's responsibilities under the Communications Satellite Act of 1962, and (5) develop and implement for the Environmental Science Services Administration (ESSA), Department of Commerce, the operational meteorological satellite system.

Communications Satellites offer the possibility of direct voice broadcasting to all parts of the world. Meteorological satellites offer the possibility of predicting weather conditions on a global basis, provide data on hurricanes, typhoons, cyclones, and other destructive weather disturbances. Applications Technology Satellites offer the means to test various techniques and scientific and technological experiments at medium and synchronous altitudes. Navigation satellites would provide traffic control, search and rescue, and communication systems for aircraft and ships. Geodetic satellites offer the means to determine the size and shape of the earth and the vector properties of its gravitational field. Earth resources survey via satellite would offer valuable data in such areas as agriculture and forestry; geology and mineralogy; hydrology and water resources; geography and cartography; and oceanography.

Resources Required:

	(Thousands of Dollars) 1966	1967	1968
Supporting research and technology	$10,839	$11,630	$16,600
TIROS/TOS improvements	2,500	3,100	7,500
Nimbus:			
Nimbus A-D	22,560	23,400	29,500
Nimbus E and F	---	---	5,000
Meteorological soundings	2,730	3,000	3,000
French satellite (FR-2)	---	100	100
Applications technology satellites:			
A-E	34,431	28,470	19,800
F and G	---	---	15,700
Geodetic satellites (A-E)	4,993	1,600	4,700
Voice broadcast satellite	---	---	2,300
Total	$78,053	$71,300	$104,200

Funds Required:

Supporting Research and Technology

The Supporting Research and Technology effort is being conducted in six areas: Meteorology, Communications, Navigation, Applications Technology, Earth Resources, and Geodesy.

In Meteorology, the areas of endeavor are to: (1) develop and evaluate components for potential meteorological satellite system application; (2) design and develop satellite sensors for the detection and controlled acquisition of meteorological data directly from the atmosphere and from other sources; (3) investigate scientific techniques and tools for the systematic observation, analysis, and subsequent interpretation of meteorological atmospheric phenomena; and (4) conduct system optimization analyses.

In Communications, the effort is primarily in the active satellite area. The objectives are to: (1) make system comparison studies to determine the merits of advanced concepts and techniques applicable to small terminal multiple access communications and satellite aids to lunar and planetary communications; (2) evaluate and develop components and subsystems required for broadcast applications and future communications systems; (3) study propagation effects and develop components and subsystems in the frequency region between 10 to 100 GHz in order to make more frequencies available for space communications; and (4) improve interference analysis and prediction methods needed for developing frequency sharing criteria. Data analysis consisting of reliability, spacecraft degradation, and lifetime data for ECHO-II, RELAY, and SYNCOM will continue in FY 1968.

In Navigation and data collection, the efforts are to: (1) conduct studies and experiment development on data and voice transmission systems to relay information via satellite to ships, aircraft, and other mobile platforms; (2) develop space technology to provide position determinations for ships and aircraft; (3) pursue studies of future navigation and traffic control satellite concepts; and (4) design systems for the collection and retrieval of data from moving platforms such as balloons, ocean-going buoys, ships, and aircraft.

In Applications Technology, the endeavors are to: (1) perform systems studies directed at improvement of stabilization techniques for spacecraft; and (2) study spacecraft equipment to improve amplification and antenna system capabilities and to increase useful lifetime.

The Earth Resources effort was budgeted under Apollo Applications prior to FY 1968. Its objectives are to: (1) develop remote sensing devices such as high resolution and multispectral cameras, radar, infrared, and other devices for obtaining data via satellite in the fields of agriculture and forestry, geography, geology, hydrology, and oceanography; and (2) conduct studies leading to improved interpretation techniques for remote sensor data, and definition of programs in the various disciplines.

The Geodesy efforts are to: (1) conduct studies, feasibility analyses, and configuration definition of geodetic spacecraft; (2) analyze geodetic requirements by various disciplines in terms of spacecraft mission and instrumentation configuration; (3) analyze the feasibility and effectiveness of geodetically optimized ground-based spacecraft observation systems, and of data analysis techniques for active and passive geodetic satellites; and (4) undertake research into the geodetic effectiveness and feasibility of advanced observation systems and techniques, to provide more precise and detailed measurement of geodetic data and to calibrate geodetic observation methods intended for extraterrestrial use. Funds are required in FY 1968 to continue or initiate new effort in the above endeavors.

TIROS/TOS Improvements

The objective of the project is to provide the technology needed to meet the meteorological requirements for the establishment, operation, and improvement of an operational satellite system for imaging the atmosphere over the entire globe regularly and dependable. Funds for FY 1968 are required to complete development and qualification of the TIROS M spacecraft and to continue effort on TOS Improvement subsystems.

Nimbus

The objectives of Nimbus are to: (1) develop a spacecraft with adequate power supply and stabilization to test a number of meteorological sensors; (2) develop a variety of meteorological sensors to obtain day and night cloud cover, and atmospheric data such as temperature, wind, water vapor, and pressure at various altitudes over the globe; and (3) test these sensors, associated data acquisition, and data handling techniques prior to recommending their use on the operational systems of ESSA.

In FY 1968, funds are required for data processing from Nimbus II, spacecraft and experiment development, integration and test of Nimbus B, development of Nimbus D spacecraft and experiments, final definition and design studies for Nimbus E and F, and initiate procurement of long lead time experiments.

Meteorological Soundings

This project consists of the following areas of effort: (1) large research rockets; (2) small developmental sounding rockets; and (3) field experiment support. The objectives are: (1) to use large research rockets to explore atmospheric characteristics, to develop and improve sensors and techniques for measuring the characteristics of the atmosphere in the region 30 to 60 miles above the earth; (2) to develop small meteorological sounding rockets for a reliable, inexpensive, self-sufficient system, which will provide routine measurements of the basic atmospheric parameters in the region 20 to 40 miles above the earth; and (3) to provide field experiment support for conducting sounding rocket experiments in cooperation with other countries, on a cost-sharing basis. The FY 1968 funds are required to provide for the launch of approximately 50 large research rockets, a number of small developmental rockets, and for continuation, extension, and development of field extension, and development of field experiment support jointly with countries in South America, Europe, and Asia.

French Satellite FR-2

The objective of this project is to provide for U.S. cooperation with France in a space meteorology experiment involving free floating balloons and an earth orbiting satellite. The objective of the experiment is to provide the in situ speed and direction of air masses at various altitudes. These data will assist in understanding the structure of the atmosphere and extending the weather forecasts. France will design, build, test, and launch the balloons; design, build, test, and deliver the satellite to the U.S. launch site; and provide NASA the technical data acquired. NASA will provide a Scout vehicle, backup vehicle, launch services, technical assistance during the spacecraft development and test phases, and assist in data acquisition and analysis. One launch, with backup if required, is scheduled for 1969. Funds for FY 1968 are required to continue analysis of balloon and spacecraft antenna, electronics, balloon position fixing techniques, data collection system comparison and general project support.

Applications Technology Satellites

This project includes the design, development, launch, and evaluation of seven spacecraft capable of performing communications, meteorological, gravity gradient stabilization, scientific, and other technological experiments. The FY 1968 funds are required for spacecraft development, gravity gradient stabilization development, scientific and other technological experiments, and for operational support of the first five spacecraft. Also, FY 1968 funds are required for a detailed study, analysis and preliminary design of the last two satellites, associated ground system modifications, and initial experiment definition.

Geodetic Satellites

The objectives of the Geodetic Satellites project are to: (1) support the acquisition of geodetic measurement data required by the investigations in geometric geodesy, gravimetric geodesy and system intercomparison, and (2) evaluate the application to geodesy of such instrumentation as radar/laser altimeters, lasers and unified S-band tracking techniques, and the application of basic satellite geodesy systems to support a world-wide time and frequency calibration, and synchronization standard. Four GEOS type launches are scheduled for the 1968-71 period. Funds for FY 1968 are required for completion of GEOS-B spacecraft and for launch support, data analysis from GEOS-I and PAGEOS-I, and for initial hardware procurement for GEOS C-E.

Voice Broadcast Satellite

The objectives of this project are to develop the capability and demonstrate the feasibility of broadcasting aural program material directly to conventional FM and/or shortwave AM radios. The spacecraft transponder could be made wideband to make possible an alternative mode permitting transmission of wideband program material to specially designed receivers for experimental purposes.

Two flights are presently scheduled for the 1971-72 period which will carry the necessary equipment aboard a large spacecraft structure to demonstrate the capability for transmission of aural program material via satellites to radios on earth. An active spacecraft stabilization system is planned, but passive control system augmentation is also being considered. A large aperture spacecraft antenna and a high power transmitter are required to provide signals of sufficient magnitude to be received by the receiving systems. In addition, antenna pointing and orientation systems will provide efficient transmission of aural program material to specified areas. Since the power required for aural broadcasting will be several kilowatts, both large sun oriented solar cell arrays and body mounted solar converters will be considered. Voice broadcast satellites in various orbits are being studied. The results of these efforts will be used in selecting the orbit for the project. In FY 1968, funds are required for definition studies and system analysis.

BASIC RESEARCH PROGRAM

Program Objectives:

The Basic Research program supports fundamental research in the physical and mathematical sciences. It is aimed at providing an understanding of the physical phenomena pertinent to other NASA programs concerned with current and future aircraft and space activities. This basic research is carried out principally in NASA's Research and Flight Centers with some contract assistance by universities, industrial research laboratories, and other Government research centers. Since fundamental understanding of physical phenomena in many fields of science is required to develop the technology for NASA's programs, basic research in NASA encompasses a wide spectrum of disciplines. It ranges from very fundamental studies into the nature and properties of atoms and molecules to the more applied research areas of determining the best materials for the supersonic transport airplane. Although much of the Basic Research program cannot be identified with current NASA projects, it increases knowledge of those scientific areas related to NASA's missions.

Resources Required:

	(Thousands of Dollars) 1966	1967	1968
Supporting research and technology	$22,000	$21,465	$23,500
Total	$22,000	$21,465	$23,500

Funds Required:

The Basic Research program is divided into four broad disciplines: Fluid Physics, Electrophysics, Materials, and Applied Mathematics.

Fluid physics phenomena of significance to aircraft and spacecraft propulsion and power generation, as well as to atmospheric entry dynamics, communication and simulation in laboratory tests, are being pursued in the disciplines of fluid mechanics, aerodynamics, and gaseous physics.

Electrophysics is a research program to attain a better understanding of the interaction of acoustic, magnetic, electric, nuclear and gravitation forces with the electrons and ions of the atomic and molecular constituents of solids, liquids, and gases. This new information is the basis for advancing the state of knowledge of various technologies, especially electronics, space power systems, and propulsion.

The broad goal of materials research is to understand the behavior of materials under the diverse environmental conditions encountered in aerospace missions. With such an understanding, materials can be rationally designed to cope with high vacuum, high temperature, ionizing radiation, micrometeorite impact, corrosive fluids and electromagnetic fields.

The basic research program in applied mathematics is concerned with the investigation and development of mathematical techniques necessary for application to the many problems of science and technology which arise in connection with the aerospace missions of NASA. Mathematical research is extremely valuable in that firm bases for continued research in the other disciplines of science and engineering are provided and, in many instances, significant economies are achieved through the elimination of costly non-mathematical experimentation.

SPACE VEHICLE SYSTEMS PROGRAM

Program Objectives:

The objectives of this program are to identify and solve critical space vehicle design problems associated with launch and exit through the atmosphere, flight through space, entry into the atmosphere of the earth and other planets, and landing. The program is directed toward advancing the technology for future space vehicles and missions and toward supporting and improving the capabilities of current vehicles.

Research using a variety of advanced ground-based facilities is conducted in spacecraft and launch vehicle aerothermodynamics and structures and in a number of space environmental technological areas, such as high-energy radiation and meteoroids. Selected critical flight experiments are carried out in close association with the ground-based research to verify and extend the laboratory results. The new research knowledge from these and other efforts is combined with design and operational experience to produce formal, authoritative design criteria to insure reliable and efficient space vehicles.

Resources Required:

	(Thousands of Dollars) 1966	1967	1968
Supporting research and technology	$26,450	$26,635	$29,000
Lifting body flight and landing tests	1,000	1,000	1,000

(cont.)

	1966	1967	1968
Scout re-entry project	3,000	4,050	4,500
Small space vehicle flight experiments	3,000	2,250	2,500
Project Fire	50	---	---
Project Pegasus (Saturn-launched meteoroid experiment)	1,500	---	---
Total	$35,000	$33,935	$37,000

Funds Required:

Supporting Research and Technology

The requested funds support an ongoing program of research and advanced technology in space vehicle aerothermodynamics, structures, and space environmental factors, and a related program to develop authoritative space vehicle design criteria. The overall program is carried out at all major NASA centers and is focused on foreseen and the most pressing technological needs of the advancing national space program.

In FY 1968 special attention will be given to advanced terminal descent systems such as the flexible parawing to permit the recovery of manned spacecraft on land. Research will also be continued on advanced manned spacecraft concepts for near-earth application having improved maneuvering performance during atmosphere entry. Research on easily refurbished ablative heat protection systems for recoverable spacecraft will be conducted.

Work will be continued on the entry of probes into the atmosphere of Mars and on atmospheric retardation techniques for soft-landed instrument packages. Research will be conducted on heating and the design of heat protection systems for vehicles entering the atmosphere at the very high speeds of return from planetary flight.

Attention will be given to the structural and thermal control problems of large orbiting telescopes. Research will continue on advanced concepts of lightweight erectable structures for applications such as very large orbiting radio-telescope antennas.

Substantial research efforts will continue on the effects of various space environmental factors on manned and unmanned spacecraft and their systems and on means of protection and control. Research will be conducted on high-energy proton and electron radiation and improved shielding techniques. Effort will continue toward further enlarging of the knowledge of the meteoroid environment and to evolve reliable but lightweight protection against meteoroid penetration.

The advancing program for development of authoritative design criteria to improve space vehicle reliability and efficiency will continue.

Lifting Body Flight and Landing Tests

The M-2 and HL-10 manned research vehicles, representing concepts of future spacecraft with improved atmospheric maneuvering capability, were constructed to investigate the problems of approach and landing and flight characteristics in the transonic regime. Both vehicles have been flown successfully in glides from air drops at Flight Research Center. The continuing program will include exploration of vehicle behavior through the transonic speed range and the expected addition of a third test vehicle, the SV-5, supplied by the Air Force.

Scout Re-entry Project

Scout-launched anchor-point flight experiments in entry heating and heat protection system performance are conducted to correlate, verify, and extend laboratory results. FY 1968 funds support two flight experiments to determine the heating rates associated with turbulent boundary layers at high Mach numbers and to determine the conditions under which transition from laminar to turbulent flow takes place. Also provided for is the development of intermediate re-entry speed experiments to determine heat shield performance and the interaction between the external flow field and ablating surfaces for application to the problem of re-entry at 50,000-plus feet per second.

Small Space Vehicle Flight Experiments

A program of selected flight experiments using small sounding rocket types of launch vehicles and other techniques is carried out to provide data needed under actual flight conditions. Principal effort in FY 1968 is a continuing series of balloon- and rocket-launched parachute and decelerator experiments to investigate deployment, loads, and stability at high altitudes where atmospheric density is representative of that expected on Mars.

Also included are a series of ablation materials performance experiments at intermediate speeds which aid in linking ground-based research with the higher speed Scout-launched experiments.

ELECTRONICS SYSTEMS PROGRAM

Program Objectives:

The purpose of the program is to establish the knowledge and technology which will fulfill the requirements of future space and aeronautical systems. Research is performed both in-house and under contract in the areas of guidance, control, communications and tracking, instrumentation, data processing, and electronic components. Flight experiments are employed to substantiate experimental results obtained in laboratory investigations and to acquire environmental data needed to design advanced sensors or systems.

Guidance research is directed toward the definition of requirements and characteristics of future space guidance and navigation systems, and developing the system elements capable of attaining these goals. Analytical studies establish performance goals of the sensors and concepts developed through research in inertial, optical, and electromagnetic phenomena. Research in control and stabilization develops the technology for space and aeronautical control systems for both manned and unmanned vehicles.

Communications and tracking system research provides the technology for future system configurations through a broad program of study and development extending over most of the electromagnetic spectrum. The efforts include research on antennas, active energy sources, and information theory.

New components, which exhibit greater reliability, and increased operating life are necessities. Research in electronic techniques and components centers on the electrical characteristics of materials, manufacturing processes, and inspection techniques to meet these objectives.

Resources Required:

	(Thousands of Dollars) 1966	1967	1968
Supporting research and technology	$29,848	$31,797	$39,200
Flight projects	2,452	1,800	1,000
Total	$32,300	$33,597	$40,200

Funds Required:

Supporting Research and Technology

Funds in fiscal year 1968 will expand support of guidance research in advanced inertial systems, optical sensors, and navigation techniques.

Long life control systems; precise pointing techniques; and simple, economical controls and displays for general aviation aircraft will require continuing support. Development of advanced spacecraft antennas, energy sources, and optical technology for space astronomy and communications will receive increased emphasis in fiscal year 1968. Computer memory concepts, offering reduced size, weight, and power consumption, and improved data handling techniques, will require increased support as will the continued exploitation of advanced technology for instrumentation applications. Fiscal year 1968 funds will expand research for reliable components and seek solutions to interconnection problems of integrated circuits. New components capable of surviving extreme temperatures will receive increased emphasis. Systematic study and development of integrated avionics systems for advanced aircraft will require expanded support.

Flight Projects

Radio attenuation characteristics of spacecraft entering the earth or planetary atmospheres is a continuing problem in spacecraft communications. Project RAM (Radio Attenuation Measurement) launches are scheduled in 1967 and 1968 to investigate this problem at velocities of 28,000 feet per second. Funds are requested for a second launch in 1968 if required and to complete data reduction and evaluation of experimental results.

Project Scanner provided limited verification of the existence of relatively stable gradients in the earth's radiation profile which can be used to design precise horizon sensors. Statistical evaluation of these gradients over a wide range of seasonal and geographical conditions is the objective of the Earth Coverage Horizon Measurement experiment. Advanced studies to determine feasible experiments have been initiated. Funds are required in fiscal year 1968 to begin project definition studies.

HUMAN FACTOR SYSTEMS PROGRAM

Program Objectives:

This program has four major objectives: (1) to determine man's reactions to the unique environments of space and aeronautical flight; (2) to define the essential requirements for sustaining and protecting man in these environments; (3) to develop the technology necessary to provide suitable life support and protective systems; and (4) to integrate man's capabilities with those of machines to obtain composite systems of superior performance.

The success, and the spectrum of missions-of-choice available to future aeronautical and manned space missions are dependent upon the timely solutions to these technology problem areas: physiological effects, human engineering, extravehicular technology, personal protective systems, and life support. The understanding of the physiological effects on man as he responds to long term manned space flight and future aeronautical flight regimes is necessary for effective integration of man as a functional part of the total system. Human engineering is essential to human factors in aviation, maintainability in space, and for the appropriate design for man in the man-machine complex. Extravehicular technology provides the astronaut with work aids, translation devices and other astronaut augmentation systems for use in free space as well as lunar surface environments. Protective systems provide the astronaut with protection from all noxious environmental factors and with personal life support systems. Life support is one of the most difficult technology areas because of the many subsystems capabilities that must be integrated as a functional system in the spacecraft.

The Human Factor Systems Program is accomplished through a multidisciplined approach including research in medicine, biology, psychology, engineering, physics, and electronics located in NASA Centers, Department of Defense aerospace medical facilities, universities, and industry.

Resources Required:

	(Thousands of Dollars) 1966	1967	1968
Supporting research and technology	$13,000	$14,675	$19,500
Small biotechnology flight projects	1,900	1,500	1,500
Total	$14,900	$16,175	$21,000

Supporting Research and Technology

This is an integrated program directed toward the accomplishment of the four major objectives of the overall Human Factor Systems Program. The program includes effort toward the definition and understanding of the effects of advanced aerospace flight on man brought about by altered and zero-gravity, spacecraft atmospheres, stress, radiation, and noise. Suitable and protective life support systems are developed and tested. The research involved covers cardiovascular and respiratory physiology, radiobiology, water and waste management, oxygen regeneration, air pollution control, space suits, systems to sustain life, extravehicular equipment and studies of man-machine interactions. The research is directed toward defining and solving next-generation aerospace problems.

Small Biotechnology Flight Projects

These projects cover a continuing series of small flight experiments designed either to validate results of laboratory research or to obtain essential information not obtainable from research in the laboratory. Work on experiments in FY 1968 will include the measurement of physiological processes in humans and animals under conditions of stress encountered in aerial and space flight and tests of life support and protective equipment designed for zero-gravity.

SPACE POWER AND ELECTRIC PROPULSION SYSTEMS PROGRAM

Program Objectives:

Current space power system technology is not yet satisfactory for such future space missions as high power, direct broadcast communications satellites, science probes and orbiters to the distant planets and long duration manned earth orbital, lunar and planetary missions. The space power program provides the research and technology necessary for the improvement and/or development of a limited number of solar, chemical and nuclear systems at a rate consistent with the estimated mission requirements ranging from watts to kilowatts in the early 1970's to megawatts in the 1980's and 90's.

The electric propulsion part of this program provides research and technology leading to the early application of small solar powered, electric thrustor systems for spacecraft position control; and development of both solar (kilowatt class) and nuclear (kilowatt and megawatt class) powered primary propulsion systems. The unique capability of some kinds of electric thrustors to develop very low thrust levels (10^{-5} to 10^{-6} pounds) for attitude and position control, and the high specific impulses obtainable from all electric thrustors offer promise of significant improvements in spacecraft operational simplicity, weight, trip time and payload.

Resources Required:

	(Thousands of Dollars) 1966	1967	1968
Supporting research and technology	$38,200	$34,940	$34,200
SNAP-8 development	4,000	5,500	9,700
Space electric rocket test (SERT)	3,000	---	1,100
Total	$45,200	$40,440	$45,000

Funds Required:

Supporting Research and Technology

The purpose of the nuclear electric power generation technology program is to provide a broad option and design basis for the selection and evaluation of energy conversion equipment to be used in conjunction with AEC developed isotope or reactor heat sources. The energy conversion systems and concepts receiving primary emphasis include (1) the Brayton cycle gas turboelectric system, (2) the Rankine cycle alkali metal turboelectric system, (3) thermionic direct conversion systems and (4) the magnetohydrodynamic (MHD) concept. Since nuclear space power systems are compact and entirely self-contained and therefore not dependent upon the sun, they are required for missions to the more distant planets where the available solar energy is very low or for near-earth missions requiring extended dark time operation.

The purpose of the solar electric power generation technology program is to broaden the existing technology base to meet the high power, long life requirements anticipated for the 1970's. Primary emphasis is on solar cell power systems up to 50 kilowatts in size. Major areas of work include solar cell array deployment concepts, compact storage and reduced assembly cost in order to make such high power systems practical. In addition, work is needed on high power electric regulation and distribution equipment to complement the high power solar cell array program. Much of this high power regulation and distribution equipment work is also applicable to nuclear power system generation technology.

The chemical power generation technology program is concerned primarily with reducing battery and fuel cell specific weight and increasing life and resistance to the space environment. Major areas of work include sterilizeable and impact resistant batteries for planetary landers, low and high temperature batteries, hybrid metal/gas batteries for decreased weight, long life fuel cells with improved off-design performance, and a basic electro-chemistry program to guide rational choices of new electrolytes and electrodes for both fuel cells and batteries.

The electric thrustor system program is aimed at the early application of small thrustors for spacecraft position control and the eventual use of electric thrustors for spacecraft propulsion beginning with relatively low powered, unmanned solar electric systems and ultimately unmanned and manned nuclear electric powered systems. Major areas of work include resistojet and electrostatic thrustors for spacecraft position control and electrostatic and electromagnetic (MHD) thrustors for spacecraft propulsion.

SNAP-8 Development

The objective of this project is to obtain the technology leading to the eventual development of a 10,000 hour, 35 electrical kilowatt nuclear electric generating system suitable for space applications in the mid-1970's and beyond. Current emphasis is on component and system technology, including both performance and endurance. Technical problems requiring correction have been identified in the present turbine mechanical design and a life problem has been found to exist in the boiler tubes. Corrective actions are being taken in both areas, as well as continuing endurance tests on other major components such as the alternator, pump and condensor.

Space Electric Rocket Test (SERT)

The overall objective of the SERT flight program is to provide information on the operations of electric thrustor systems in the space environment. SERT I successfully demonstrated that an ion beam could be neutralized in space. A second flight is planned for 1969 to provide a long term evaluation (minimum of six months) of the performance and reliability of an ion thrustor system and to study the effects of ion engines on other spacecraft components such as radio frequency interference. Current plans are to utilize and THORAD-Agena vehicle.

NUCLEAR ROCKETS PROGRAM

Program Objectives:

The Nuclear Rockets program develops the necessary research, design and engineering data, test hardware and general technology of nuclear engine systems utilizing graphite solid core reactors for possible advanced space missions and investigates and evaluates advanced reactor concepts which may offer improvements in nuclear rocket propulsion technology.

Through the use of nuclear rocket propulsion, significant performance advantages accrue to many possible advanced space missions such as lunar logistics operation, deep space probes, with heavy spacecrafts and manned exploration of the planets.

The major areas of effort are the research and engineering of the nuclear reactor, the development of certain non-nuclear components, and the integration of the reactor and non-reactor components into a complete experimental engine system.

This program supports the objective of continued development of nuclear rocket technology for possible future use. However, if a a decision is reached to proceed with the development of a nuclear rocket engine, an activity carried under allowance for contingency in the overall national budget, the program described herein will provide the logical nuclear rocket technology support.

Resourced Required:

	(Thousands of Dollars) 1966	1967	1968
Supporting research and technology	$20,644	$16,506	$16,500
NERVA	35,356	33,494	26,000
NRDS operations	2,000	3,000	4,000
Total	$58,000	$53,000	$46,500

Funds Required:

Supporting Research and Technology

The supporting research and technology effort supplies three basic needs: (1) general supporting research and technology data for current projects; (2) basic technology for the development of future generations of nuclear rocket engines and vehicles; and (3) feasibility analyses of advanced nuclear propulsion concepts.

This effort also includes special studies of safety problems associated with the overall nuclear rocket program.

NERVA

The objective of the NERVA technology effort is to develop the technology of nuclear rocket engine systems utilizing graphite solid core reacotrs. During FY 1968, effort will be directed towards the test activities required to satisfy the remaining objectives of the NERVA technology program. The objectives of these tests include determination of the most desirable techniques for starting and controlling a nuclear rocket engine, demonstration of shut down techniques and demonstration of the capabilities of the downward firing test stand.

NRDS Operations

The mission of the Nuclear Rocket Development Station (NRDS) is to provide a site for ground static testing of the reactors, engines, and eventually the propulsion stages associated with nuclear rocket development. The funds under this project provide for NASA's share of the general site operation, the major part of which is now funded by the AEC.

CHEMICAL PROPULSION PROGRAM

Program Objectives:

Propulsion represents one of the greatest limitations in capability for exploring space. Chemical fuels and oxidizers are the basis for today's total space capability. Chemical engines are the only useable propulsion systems for space vehicle launches in the foreseeable future. The realization of the potential inherent in chemical systems for development of future mission capability depends primarily upon increasing knowledge of chemical propulsion processes, the investigation of new concepts and techniques and adding to the store of knowledge leading to a sound technological basis for an improved system for experimental engineering work and eventually development.

Research and advanced technology covers basic studies and experiments related to aspects of launch vehicle, spacecraft or auxiliary propulsion criteria, such as measurements of chemical and physical properties of propellants, combustion phenomenon, ignition, non-equilibrium and classical thermodynamic processes, examination and development of new materials, and the processes of fluid mechanics, gas dynamics, heat transfer, and solid mechanics. Analyses are made of the functions of space propulsion system must perform, the performance levels that can be met and in the broad cycle efficiency sense, the conditions under which it might best perform. New methods and design concepts are assessed. Future requirements and new problem areas are identified for further work.

The experimental engineering program bridges the technological gap between propulsion research technology and the initiation of mission oriented propulsion system developments. The work involves the design, fabrication and test of experimental propulsion systems and of subcomponents to determine and demonstrate practicability of the engineering aspects to meet known or foreseen requirements of launch vehicles, and engines for upper stage and spacecraft. Tests of experimental systems are required in the evolution process necessary to produce advanced propulsion designs with operating parameters and selection of a design for development and use. Design criteria, preliminary engineering specifications, fabrication process specifications and ability to evaluate and analyze development requirements, costs and schedules, and facility and equipment needs are developed in this phase of the work. The results provide a sound basis for selection of an advanced propulsion system and thereby minimize costs during the development phase.

Resources Required:

	(Thousands of Dollars)		
	1966	1967	1968
Supporting research and technology	$32,950	$30,138	$38,000
M-1 engine project	2,000	---	---
Large solid motor project	4,750	3,500	---
Total	$39,700	$33,638	$38,000

Funds Required:

Supporting Research and Technology

Advanced engine design concepts for improving vehicle performance with chemical propellants are being investigated for launch vehicle and upper stage application; the high energy propellants are being examined for use in spacecraft where high specific impulse offers significant weight savings. A liquid propellant experimental program is concentrating initially on spacecraft propulsion related to applications during the next decade. It includes examination of high performance propulsion systems using hydrogen and fluorine propellants or space-storable propellants suitable for use after extended duration flight in the space environment. The experimental program also covers work on advanced high performance engine systems that will succeed the discontinued M-1 engine.

The solid propellant motor program includes research on non-destructive testing techniques for inspection and qualification of loaded motors, ignition and instability problems, thrust vector control systems, methods of combustion termination, and improved processing techniques. New requirements under investigation are stop-restart capability, more accurate thrust alignment, and improved predictability of propellant burning rate. An experimental engineering program will develop the technology related to solid motor development to the point of demonstrated applicability to launch vehicles, spacecraft, and auxiliary propulsion use.

AERONAUTICS PROGRAM

Program Objectives:

The role of the NASA's Aeronautics program is to provide through research the technology to improve the efficiency, utility, and safety of aircraft. The program encompasses work in aerodynamics, structures, materials, air breathing propulsion, operational aspects, including safety, noise, and sonic boom, and pilot and aircraft integration. Studies in these areas point to the most profitable paths for technological advances in the future. For example, the XV-5A fan-in-wing aircraft, the tilt-wing XC-142A V/STOL transport, and the variable-sweep wing for the F-111 all appeared several years ago as NASA research concepts and in substantiating through research the over-all capabilities of practical vehicles based on these concepts.

During development of new aircraft NASA conducts extensive wind tunnel tests, simulator programs, and flight investigations using appropriate testbed aircraft to verify predicted performance and operational characteristics and to aid in the solution of problems of a developmental nature. This advanced technical development in support of military and civil aircraft procurement is performed by NASA at the request of the cognizant government agencies and in cooperation with the requesting agency's contractor.

Experimental research and development aircraft and engineering testpilot proficiency aircraft considered necessary to carry out and support the aeronautics effort are included under this program.

Resources Required:

	(Thousands of Dollars) 1966	1967	1968
Supporting research and technology	$10,186	$9,582	$18,600
X-15 research aircraft	883	878	4,000
Supersonic transport	12,331	11,090	11,100
V/STOL aircraft	3,200	5,550	7,100
Hypersonic ramjet engine	5,000	2,000	7,000
XB-70 flight research program	9,896	2,000	10,000
Aircraft noise reduction	---	---	2,000
Delta X-15 aircraft	---	---	1,000
F-111 aircraft	---	---	500
F-106 aircraft	---	---	2,000
Total	$41,496	$35,900	$66,800

Funds Required:

Supporting Research and Technology

The Supporting Research and Technology program in Aeronautics in FY 1968 includes studies directed toward improvement of subsonic, supersonic, and hypersonic aircraft. For example wind-tunnel and analytical investigations aimed at improving stability and control of general aviation aircraft; analytical studies to improve flutter prediction methods for use in the designs of transonic and supersonic aircraft; research on the development of analytical and experimental techniques to obtain more accurate methods of prediction of the dynamic response of an airplane to atmospheric turbulence; research to determine noise generation and transmission processes in fan blade rows and associated ducting; research on inlets, exits, and afterbodies typical of high bypass ratio propulsion systems anticipated for very large subsonic aircraft; research on aircraft noise alleviation both in engines and in aircraft operations; research on methods to improve control of aircraft on wet runways, in rough air and during instrument flying; and improved methods for control of future, huge jet transport aircraft will be conducted.

X-15 Research Aircraft

The X-15 Research program provides data on manned, maneuverable hypersonic flight. The X-15 provides the only means in the world for studying hypersonic flight in its true environment. Major programs which will use this X-15 capability in the future are the Hypersonic Ramjet Experiment and the advanced technology delta wing designed to investigate the programs of hypersonic cruise aircraft propulsion systems and configurations, respectively.

In addition to a continuing program in basic hypersonic flight research, the operational success of the X-15 program has opened its use to space sciences as a carrier vehicle for certain experiments requiring its unique performance capabilities.

Total funding responsibility for the operational support of the X-15 research program, conducted in cooperation with the Department of Defense since its inception, will be transferred to the NASA on 1 January 1968, for the remainder of FY 1968 and all subsequent years, in accordance with the decision of the NASA-DOD Aeronautics and Astronautics Coordinating Board. This support has cost approximately $8,000,000 per year. Therefore, operational support of the program for one-half of fiscal year 1968 is $4,000,000.

Supersonic Transport

By inter-agency agreement, NASA will continue to provide technical support and assistance to the FAA (currently the Department of Transportation) in the evolution of the U.S. prototype supersonic transport. In addition, NASA will conduct a continuing research program to provide the technology for improved and advanced airframes, propulsion systems, and operational concepts applicable to this type of aircraft. Aerodynamic research will be directed to extend the technological state-of-the-art to higher cruise speeds, increase aerodynamic efficiency throughout the speed range, and improve supersonic flow field patterns to minimize generation of sonic boom. The effects of low-density fuels such as liquid methane and hydrogen on the characteristics of the aerodynamic configuration will be determined.

Wind tunnel tests and associated direct technical support will be provided for the National Supersonic Transport Development program as required. This support will include necessary use of NASA facilities and key personnel by the FAA and its contractors in the course of prototype development.

Operational research on sonic boom will be concentrated upon further exploration of various atmospheric effects on boom signatures such as temperature, turbulence, wind shears and humidity. In addition, laboratory studies of structural response to booms and field tests of boom seismic effects will be expanded following the initiation of these programs in the later part of the present fiscal year.

The General Purpose Airborne Simulator (modified Jet-Star aircraft) and the new six-degree-of-freedom motion Advanced Aircraft Simulator will be used to investigate handling qualities problems unique to supersonic transport operations and to simulate a complete SST mission profile.

An increasingly larger in-house propulsion research effort is being conducted to provide the advanced technology required for second generation supersonic transport engines. Some of the promising compressor and turbine blade element designs will be incorporated into single stage and multistage wheels for further research, and advanced cooling techniques and the use of advanced materials will also receive consideration and study during this period.

V/STOL Aircraft

Research on V/STOL aircraft will be directed at improving the performance of the more promising types and at easing the difficult flight control problem existing during the transition from conventional flight to hover, particularly during poor or zero visibility conditions. Wind tunnel and flight research will be continued on the hingeless and jet flap rotor principles offering the potential of increasing the cruise performance of helicopters, reducing the rotor generated vibration and improving the control power. Studies will continue on the use of small wings and auxiliary thrusting devices to reduce the rotor thrust and lift requirements in cruise, and hence increase efficiency. Much of this activity will be a cooperative effort with the U.S. Army in view of the great importance of helicopters to that organization.

Studies to define acceptable handling qualities for V/STOL aircraft and studies of the way in which the various promising concepts can meet these criteria will continue with wind-tunnel models particularly aided when the new V/STOL facility comes into operation and in flight research. Flight programs using the P-1127 fighter and the XC-142A transport will be active in 1968. Through the NASA/Air Force

V/STOL Technology Panel, plans are being made for a jet-fighter VTOL research airplane program now in the feasibility study stage by NASA and AFSC.

The growing air breathing propulsion research program will expand to include research on propulsion systems appropriate for V/STOL aircraft. Lift fan types and light weight turbojets of small volume will receive special attention. Noise control will form a major constraint in this research.

Hypersonic Ramjet Engine

This project was initiated to accelerate the technological advancement of air breathing propulsion for hypersonic atmospheric flight. Three contractors participated in parallel feasibility and preliminary design studies of a liquid hydrogen fueled research engine capable of operating at speeds between Mach 3 and 8 with combustion occurring in both a subsonic and supersonic air stream. The Garrett Corporation was selected to conduct the detailed design, experimental wind tunnel verification, fabrication, and proof test of its proposed concept. This engine must be capable of withstanding the severe environment of hypersonic flight, and regeneratively cooled surfaces will be used within the engine to maintain structural integrity.

Upon delivery of the research engine to the NASA, a test program will be initiated to determine the performance levels and operational problems associated with the hypersonic propulsion system. This will be accomplished by using the X-15 aircraft as a test vehicle to obtain the necessary test environment.

XB-70 Flight Research Program

The NASA research portion of the XB-70 program began in FY 1963 with installation of instrumentation in the two XB-70A aircraft during manufacture and the subsequent acquisition of certain data during the preliminary USAF flight test program. The second phase, beginning early November 1966 consists of continuation and expansion of the initial program plus the start of research which could not be done during the USAF flight program.

In the second phase basic theories and the results of small-scale tests performed in ground-based facilities will be evaluated. Efforts will be directed toward analysis of the effects of vehicle size and weight; the effects of inertia combined with low aerodynamic damping at the higher operating altitudes of the SST; and the effects of structural elasticity and deformation on the basic aerodynamics of the vehicle. The highest priority tests during this second phase are directed toward a better understanding of sonic boom phenomena and their effect on persons on the ground.

During the first phase, NASA funded the instrumentation and data acquisition for those measurements of interest to NASA and the FAA.

The cost of operating the aircraft was funded by the Air Force. In the second phase--the present NASA-USAF XB-70 Flight Research program authorized by a NASA-DOD Memorandum of Understanding signed on 28 May 1965--the total cost of the program is shared equally by the Air Force and the NASA.

The FAA participates in the overall planning of the program, including determination of the specific program objectives and priority of the objectives and is kept informed on the progress of the program.

Aircraft Noise Reduction

Two important aspects of aircraft noise alleviation are covered by the research to be carried out in this program area (1) the research and development necessary to provide means for minimizing the noise radiated from the compressor and fan discharge ducts of turbofan engines such as are installed in presently operating commercial jet aircraft, and (2) research directed toward developing a more positive means for accurate flight path control which would be required in order to make use of steeper approach paths for landing thus increasing the distance of the aircraft from the ground in the vicinity of the airport and lowering the noise level.

Quiet Engine Development

Basic research has shown that the elements of a turbojet engine can each be modified in design to permit substantial noise reduction with small penalty in performance. Information on the successful operation of such a propulsion system is unavailable. The interaction of the various components will differ substantially from any turbojet propulsion system now in use. The objective of the Quiet Engine project is to combine all of these low noise elements into a single operating system having approximately 20,000 pounds of thrust, and designed to operate at high subsonic flight speeds.

Delta X-15 Aircraft

The NASA and the USAF have been engaged in formulating a joint long-range program planning effort on Hypersonic Aircraft Technology. A minimal contractual study was initiated in FY 1967 concerned with an analysis of the feasibility of converting an X-15 to a delta-wing configuration and the generation of preliminary and limited design data. FY 1968 funds are requested for an overall engineering design prerequisite to the fabrication and assembly of this delta-wing X-15 airplane.

F-111 Aircraft

The objectives of this program are to obtain in-flight verification and validation of wind tunnel and theoretical prediction of aerodynamic characteristics and performance of variable geometry aircraft to define areas in which more research is needed and to provide confidence for the design of future vehicles. The F-111 is the first production variable-sweep aircraft to reach flight status. A number of problems can be investigated only in flight research such as the combined and inter-related effects of aerodynamics; structures; systems; inlets and exits; and the pilot-in-the-loop. This program will be carried out using an F-111 loaned to NASA by the Air Force under a reimbursable support agreement; NASA funds the maintenance and spare parts and operational support of the aircraft.

F-106 Aircraft

To maintain a high level of performance at off-design conditions, the inlet and exhaust systems of supersonic aircraft will be required to undergo a considerable change in geometry. The performance and operation of these systems are sensitive to the manner in which they are integrated into the airframe design, and the interactions between airframe and propulsion system exert a strong influence on total performance. To study these problems, a small jet engine will be installed in a nacelle and mounted on the lower wing of an F-106 airplane in a location representative of that proposed for the supersonic transport.

TRACKING AND DATA ACQUISITION PROGRAM

Program Objectives:

The purpose of this program is to provide responsive and efficient tracking and data acquisition support to meet the requirements of all NASA flight projects. In addition, support is provided, as mutually agreed, for projects of the Department of Defense, other Government agencies, and other countries engaged in space research endeavors.

Support is provided for manned and unmanned flights; for spacecraft, sounding rockets, and research aircraft; and for earth orbital and suborbital missions, lunar and planetary missions, and space probes.

Types of support provided include: (a) tracking to determine the position and trajectory of vehicles in space, (b) acquisition of data from scientific experiments and on the engineering performance of spacecraft and launch vehicle systems, (c) transmission of commands from ground stations to spacecraft, (d) communication with astronauts and acquisition of medical data on their physical condition, (e) communication of information between various ground facilities and mission control centers, and (f) processing of data acquired from the space vehicles. Such support is essential for the critical decisions which must be made to assure the success of all flight missions, and, in the case of manned missions, to insure the safety of the astronauts.

Tracking and data acquisition support is provided by a worldwide network of NASA ground stations and control centers supplemented by instrumentation ships, aircraft, and selected ground stations of the Department of Defense. These facilities are interconnected by a network of ground communications lines, undersea cables, high frequency radio links, and communications satellite circuits, which provide the capability for instantaneous transmission of data and critical commands between spacecraft and control centers. Facilities also are provided to process into meaningful form the large amounts of data which are collected from flight projects. In addition, instrumentation facilities are provided for support of sounding rocket launchings and flight testing of research aircraft.

Resources Required:

	(Thousands of Dollars)		
	1966	1967	1968
Operations	$127,510	$197,400	$228,800
Equipment	89,755	59,650	55,100
Supporting research and technology	13,800	13,800	13,800
Total	$231,065	$270,850	$297,700

Funds Required:

Operations

Funds are required for the operation and maintenance of the worldwide tracking and data acquisition facilities. Most of the increase in the FY 1968 operations program is related to the cost of staffing and operating additional Manned Space Flight Network stations and providing communication services required for support of the Apollo program. Small increases also are included to enable the Deep Space

Network and the Satellite Network to meet the increasing support requirements of unmanned flight projects.

Equipment

The tracking and data acquisition support requirements for forthcoming missions establish the equipments that must be procured and the facilities that must be modified. Procurement of equipments to meet Apollo requirements will continue in FY 1968 as well as for the support of future unmanned missions. Funds also are needed to provide for sustaining modifications and maintenance which are continuing requirements for all tracking and data acquisition facilities.

Supporting Research and Technology

Supporting Research and Technology is the activity whereby concepts, techniques, and hardware are developed, tested, and evaluated for use in the various networks to meet support requirements of new flight projects. The program for FY 1968 will emphasize improvements for increasing the reliability and lifetime of existing systems and for determining techniques for efficient utilization of these systems to meet upcoming requirements.

TECHNOLOGY UTILIZATION PROGRAM

Program Objectives and Justification:

The primary objectives of the Technology Utilization program are to establish effective mechanisms and systems for assuring that all new scientific, technological and engineering knowledge resulting from NASA programs is identified, collected, evaluated and made available in the form which is most useful; to establish effective mechanisms for announcing and disseminating this new knowledge in order to assure the widest practical application and utilization therof; and to improve our understanding of the management of large scale research and development programs and the impact of the space program on the Nation's economy.

Resources Required:

	(Thousands of Dollars) 1966	1967	1968
Identification	$1,220	$1,265	$1,265
Evaulation	680	650	650
Dissemination	2,000	2,085	2,085
Analysis	850	1,000	1,000
Total	$4,750	$5,000	$5,000

Funds Required:

Identification

Teams of specialists from universities, research institutions and private industry, with the assistance of Technology Utilization officers at NASA Headquarters and field installations, search through selected areas of NASA scientific and technical endeavor in order to record significant NASA advances which have potential utility for the non-aerospace sector of the nation.

Evaluation

Research institutions whose services are primarily directed toward industrial clients make preliminary evaluations of technological innovations reported to NASA, analyze and formulate potential industrial uses for selected innovations, and where appropriate, prepare brief reports describing these technological advances.

Dissemination

Universities and research institutions are employed to develop regional capabilities to store, retrieve, and interpret to local industry the technology developed by NASA. These information centers strengthen our national technical resources by encouraging rapid localized application of the technology generated in the course of NASA activities. Biomedical application teams assist medical research institutions in defining medical problems in engineering terms, scour NASA technology for solutions to these problems, and then assist the medical research institutions in adapting NASA technology to practical solution of the defined problems. This pilot program started this past year is proving to be a very effective mechanism to relate NASA information to the important unmet community needs in the field of medical research and health care.

Analysis

A major area of concern is that of promoting a better understanding both within and outside the Agency of new and improved techniques for managing large and complex research and development activities. This concern has included support of research in such areas as the organization and management of large R&D projects, the diversified roles of the research director, government-industry contractors systems, and top level policy and decision making in large R&D organizations.